JMI's 6-inch binocular telescope reviewed PAGE 90

What put the boom in supernova A.D. 1006? PAGE 48

Glenn Chaple's observing basics PAGE 19

February 2004
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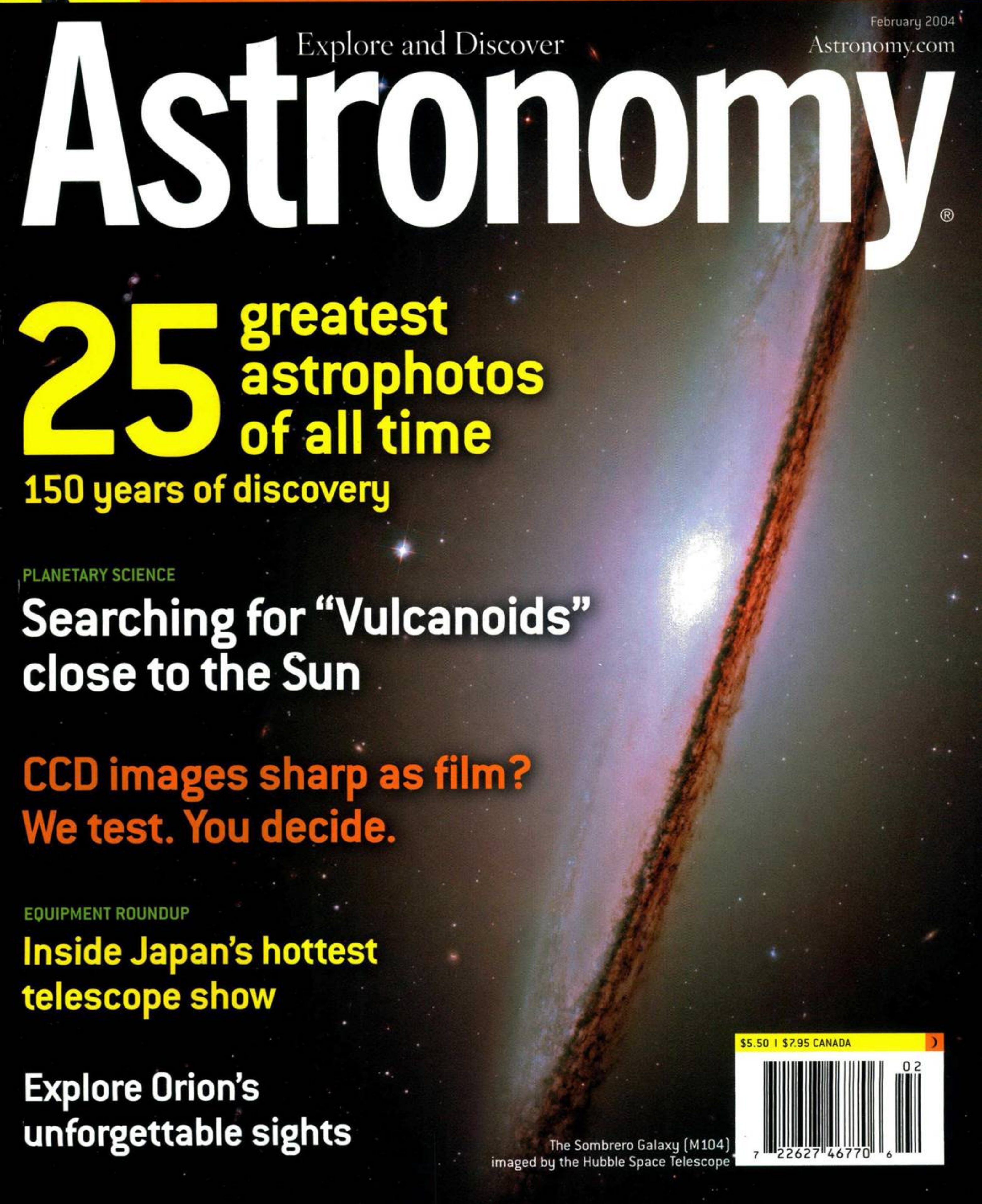

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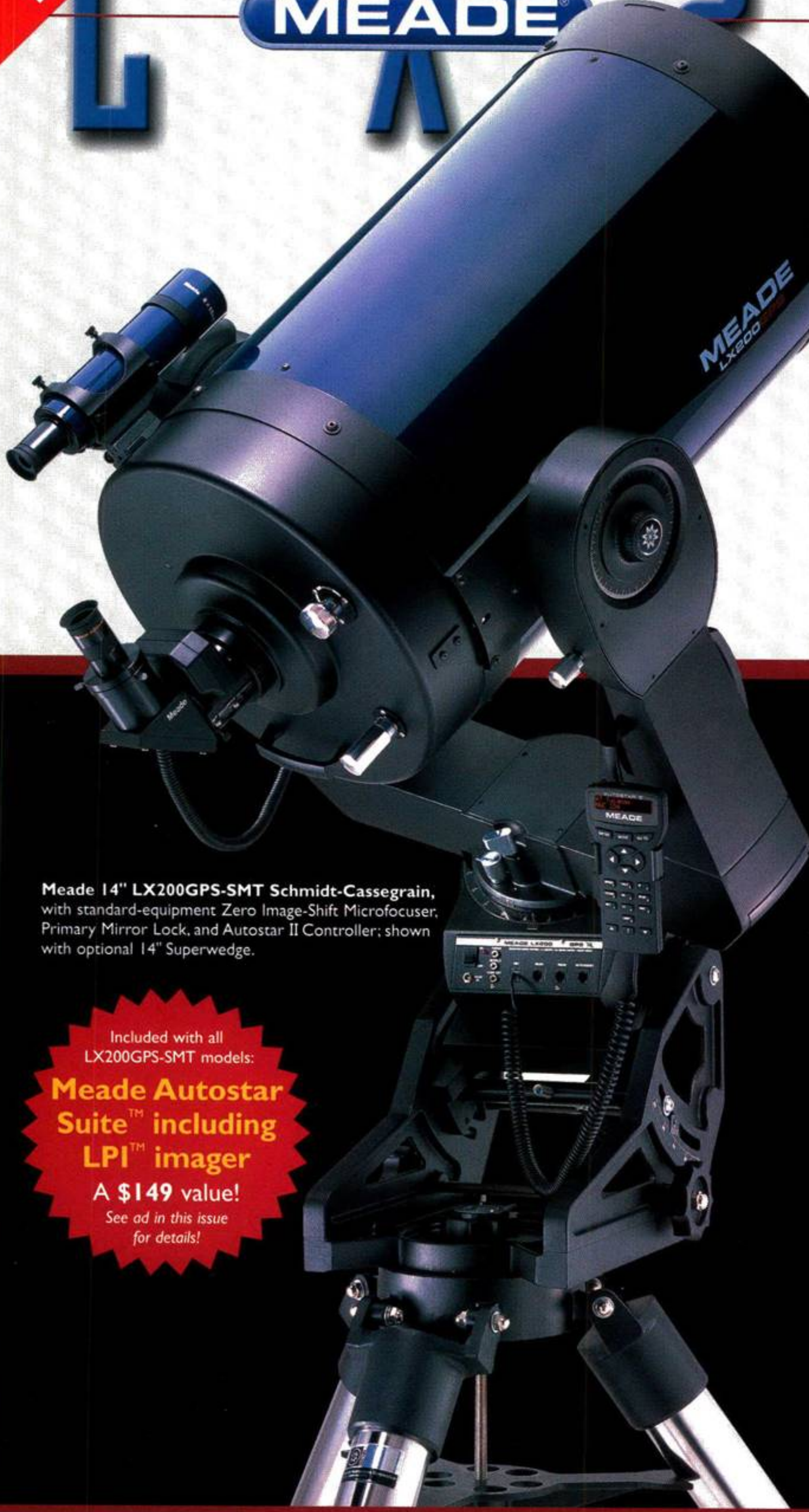

Meade 14" LX200GPS-SMT Schmidt-Cassegrain, with standard-equipment Zero Image-Shift Microfocuser, Primary Mirror Lock, and Autostar II Controller; shown with optional 14" Superwedge.

Included with all LX200GPS-SMT models:

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Packing & shipping charges in the 48 states: 8" LX200GPS-SMT – $105; 10" – $145; 12" – $215; 14" – $265; 7" – $125. Prices shown are suggested U.S. national mail-order retail prices. Certain Meade telescopes and Autostar control systems are manufactured under U.S. Patent Nos. 6,304,376 and 6,392,799; other patents pending in the U.S.A. and worldwide.

Facing page *(right to left)*: Meade 7" LX200GPS-SMT Maksutov-Cassegrain; 8", 10", and 12" LX200GPS-SMT Schmidt-Cassegrains.

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Meade Ultra-High Transmission Coatings (UHTC) Group: The optical coatings provided as standard equipment with Meade Schmidt-Cassegrains equal or exceed the reflectivity/transmission of virtually any coatings currently offered in the commercial telescope industry. Alternatively, however, the UHTC group is available optionally at the time of telescope purchase on Meade LX200GPS models and includes an exotic series of multi-layer coatings on the telescope mirrors and on the correcting lens. The UHTC group dramatically increases image brightness by about 20% across the visible spectrum. *Image brightness of the Meade 10" LX200GPS, for example, is effectively increased by about one full inch of aperture.* For a more thorough discussion of Meade's Ultra-High Transmission Coatings Group, please see our website at *www.meade.com.*

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New General Catalog (NGC)	7840
Index Catalog (IC)	5386
Uppsala Galaxy Catalog	12,940
Morphological Catalog of Galaxies	12,939
General Catalog of Variable Stars	28,484
SAO, Hipparcos, and Draper Star Catalogs	63,404
Yale Bright Star Catalog (BSC5)	6,150
Large Bright Quasars Survey (LBQS)	1055
Messier (M) and Caldwell Catalogs	219
Named Objects	227
Herschel Catalog	400
Abell Catalog of Galaxy Clusters	2712
Arp Catalog of Irregular Galaxies	645
Major planets from Mercury to Pluto	8

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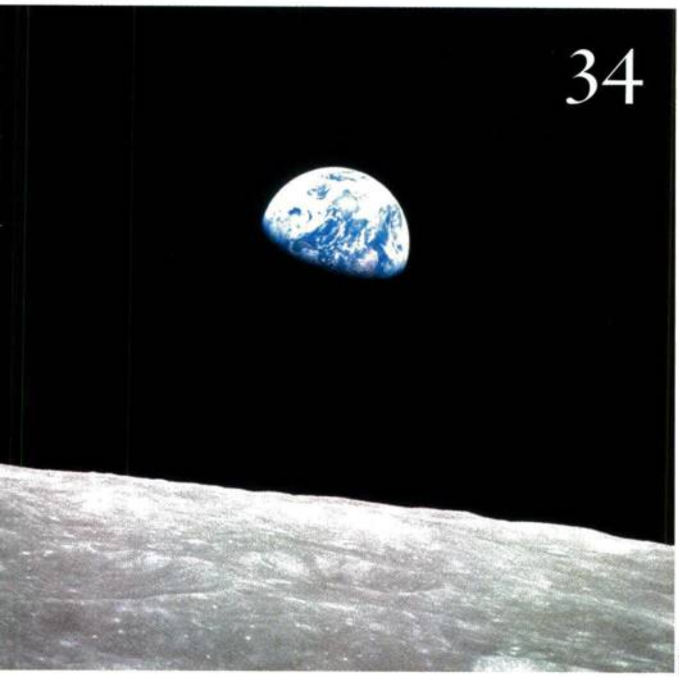
features



NASA

COVER STORY

34 The 25 greatest astrophotos in history

From the first daguerreotype of the Moon in 1840 to CCD cameras today, imaging the sky has become a science unto itself. *Astronomy* presents 25 milestone astrophotos that pushed the bounds of technology and shaped our view of the cosmos. MICHAEL E. BAKICH

PLANETARY SCIENCE

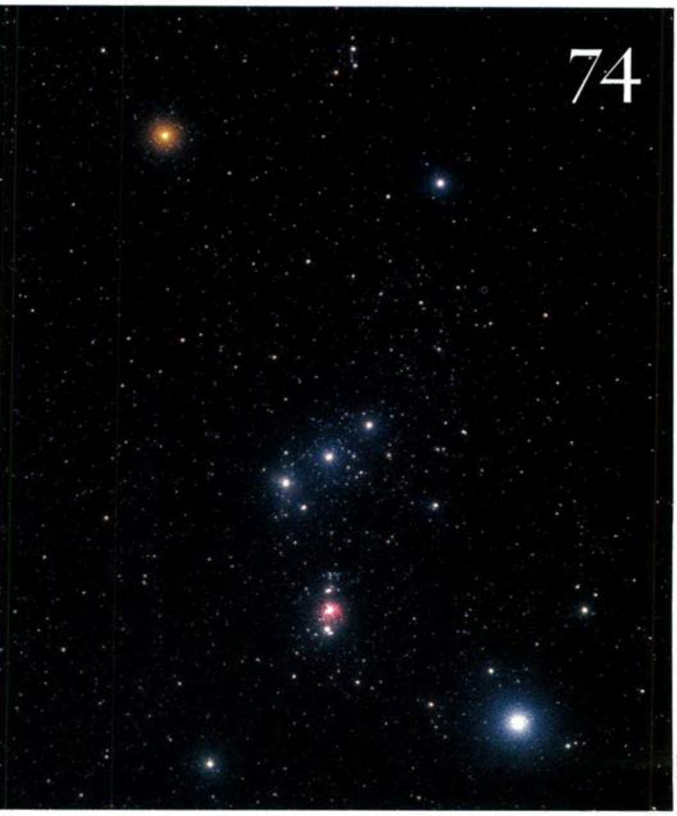
42 On the trail of Vulcanoids

A bevy of small asteroids may lurk inside the orbit of Mercury, although searches have yet to turn up a thing. Even so, astronomers continue to hunt for these objects, which could provide valuable clues about the early history of the solar system. S. ALAN STERN

GALACTIC ASTRONOMY

48 Star light, star bright

In A.D. 1006, sky-watchers in Europe, the Middle East, and Asia were startled by a bright new star. Only now, nearly a millennium later, have astronomers figured out what caused the brightest supernova known. FRANCIS REDDY



ALAN DYER

CELESTIAL PORTRAITS

74 Orion the Hunter

The Hunter's warrior robes are adorned with nebulae, star clusters, and some of the brightest stellar jewels of the winter sky. TOM POLAKIS

EQUIPMENT ROUNDUP

80 Japan's telescope show

Proving that astronomy is alive and well in the Land of the Rising Sun, Japan's leading manufacturers display their latest and greatest telescopes and binoculars. BARRY KAWA

ASTROPHOTOGRAPHY

84 CCD images at their best

Photo-realistic CCD images are now within your grasp. Let master imager Tony Hallas be your guide to creating the best digital pictures possible, and you'll never have to say "it's only a CCD image" again. TONY HALLAS

TELESCOPE REVIEW

90 JMI's RB-66 binoscope

Looking for the ultimate binoculars? *Astronomy* test-drives a connected pair of 6-inch reflecting telescopes that allows you to see wide and deep. PHIL HARRINGTON

DANIEL B. PHILLIPS

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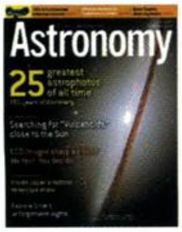

ON THE COVER

The Sombrero Galaxy (M104) in Virgo is one of the most recognizable galaxies for amateur observers. The galaxy's UFO-like disk and broad, edge-on dust lane, which helped create its nickname, can be seen even through small backyard telescopes. This Hubble Space Telescope image of M104 ranks as one of the best 25 astrophotos ever taken; see more great images starting on page 34. NASA/STScI

BY DAVID J. EICHER

Astronomy snags two Ozzies

Astronomy has been named the winner of two *Folio:Show* 2003 Ozzie® awards, prestigious recognition from *Folio:* magazine, the industry publication about magazines. *Astronomy* won the Gold award for Best Redesign in the "consumer above 100,000 circulation" magazine category and the Platinum award for Best Redesign overall.

Astronomy's redesign, introduced a year ago, was not merely a superficial reworking of design elements in the magazine. Rather, it was a repositioning to bring you more and better science stories along with greatly expanded coverage of the hobby — observing, astrophotography, telescope reviews, and how-to stories.

Folio: editors selected the Platinum award winner for Best Redesign from the winners of six categories. The awards, which recognize excellence in magazine design, were announced during the Celebration of Excellence Awards Gala on October 28, 2003, at the New York Hilton, New York City. Congratulations to art director Tom Ford, to our editorial and art staff, and to our partners in the redesign — the Iridium Design Group in New York.

Continuing our fine tradition of spectacular design in this issue is associate editor Michael E. Bakich's story "The 25 greatest astrophotos in history" on page 34. From the beginning of astrophotography in 1840, when John W. Draper snapped his initial daguerreotype of the Moon, to the present-day wonders of the Hubble Space Telescope, many millions of images have been gathered.

Narrowing the field to the 25 greatest of the last 164 years was a challenge *Astronomy*'s editors relished, and we hope you'll enjoy these memorable scenes — including a vintage 1910 shot of Halley's Comet, Apollo 8's earthrise over the Moon, and the discovery images of Pluto.

TWO OZZIE AWARDS celebrate the success of *Astronomy*'s makeover. ASTRONOMY: WILLIAM ZUBACK

Further, check out planetary scientist S. Alan Stern's "On the trail of Vulcanoids" on page 42. This solar system detective story dates to the 19th century, when astronomers first believed a giant planet, Vulcan, existed between the Sun and Mercury. Although Mr. Spock's planetary namesake doesn't exist, a sizable body of tiny asteroids — Vulcanoids — may well lie very close to the Sun. Stern's story paints an intricate picture of where scientists are in the hunt for Vulcanoids and why we should care if they're there.

As always, I invite you to contact me with comments about the magazine. E-mail me at editor@astronomy.com.

Yours truly,

Dave Eicher
Editor

Astronomy
VoL. 32 No. 2

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A long listing of standard-equipment features including rigid fork mounts; dual-axis drive systems with high-torque DC motors on both telescope axes; cordless field operation from eight (user-supplied) AA-batteries that power the telescope for more than 20 hours of normal usage; and internal flip-mirror system for observing or imaging from either the 90° or straight-through positions.

#497 Autostar Controller: The patented Meade Autostar controller brings automatic GO TO operation, plus dozens of additional menu options, to your fingertips, with a database of more than 30,000 celestial objects, including 5,386 galaxies, nebulae and star clusters from the Index Catalog (IC); 7,840 objects from the New General Catalog (NGC); 110 Messier objects; the major planets from Mercury to Pluto; and more.

#884 Deluxe Field Tripod: Constructed of strong, lightweight steel, the full-length Meade #884 Deluxe Field Tripod provides a rigid mounting platform for virtually any ETX observing application. Tripod height is adjustable for seated or standing observing. Use in either equatorial or altazimuth orientations; a graduated scale permits precise polar alignment. For Autostar applications, or for terrestrial observing, the tripod locks to 90°.

Each supplied with #497 Autostar Controller and #884 Deluxe Field Tripod:

ETX-90AT Astro Telescope	**$595**
ETX-105AT Astro Telescope	**795**
ETX-125AT Astro Telescope	**995**

Ultra-High Transmission Coatings (UHTC) group increases image brightness by about 20%: ETX-90AT– $50; ETX-105AT– $75; ETX-125AT– $95

Alternately, for the beginning-to-intermediate observer, the ETX-70AT is supplied with #494 Autostar Controller and #882 Field Tripod:

ETX-70AT Astro Telescope	**299**

Packing & shipping (ETX, Autostar, & Tripod): ETX-90AT — $30; ETX-105AT — $35; ETX-125AT — $40; ETX-70AT — $20.

Meade ETX-125AT
Shown with standard-equipment #497 Autostar Controller and #884 Deluxe Field Tripod.

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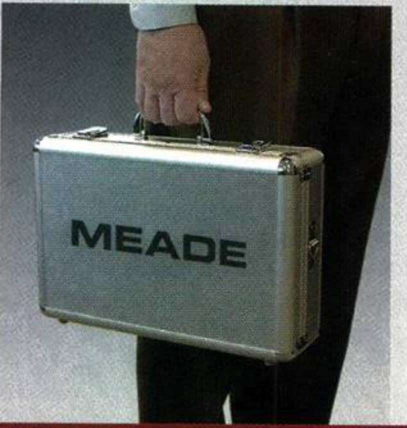
SUPER PLÖSSL 40mm

Now for a limited time, to celebrate Meade Instruments' 30 years in telescopes, you can buy a Meade telescope* and receive a full set of Meade premium-grade Super Plössl eyepieces for only $99 additional. Never before have we made such an incredible offer available for such a wide range of our most popular telescope models.

Choose from more than a dozen qualifying Meade telescopes *(see listing at right)*, mail us your check for $99, and we'll ship your Super Plössl eyepiece set directly to you. And we'll pack your eyepieces in the Meade #771 foam-lined aluminum carrying case, itself a $49.95 value if purchased separately. For complete details see the HOW TO ORDER box at right.

Designed and manufactured to exacting standards, Meade Series 4000 Super Plössl eyepieces deliver wide 52° apparent fields (44° for the SP40mm) with all of the resolution, edge-of-field sharpness, and color correction demanded in the most advanced visual applications. All eyepieces are brand-new and factory fresh; each is multi-coated, includes a soft rubber eyeguard, and is individually packed in a thread-on poly container. There are no finer general-purpose eyepieces available.



The Meade #771 aluminum carrying case, included with this special offer, provides rugged, secure storage for your Super Plössl eyepiece set.

This special offer includes the following eyepieces:

SP6.4mm	$79.95
SP9.7mm	79.95
SP12.4mm	79.95
SP15mm	79.95
SP20mm	79.95
SP26mm	(standard equipment)**
SP32mm	99.95
SP40mm	99.95
#771 Aluminum Carrying Case	49.95
Total price if purchased separately:	**$649.60**

***Telescopes qualifying for this special offer include:**

ETX (EC or AT) models: ETX-90, ETX-105, ETX-125
LXD55 models: 6" SN-6, 8" SN-8, 10" SN-10, 8" SC-8, 5" AR-5, 6" AR-6, 6" SN-6EC, 8" SN-8EC, 5" AR-5EC
LX90, LX200GPS models: 8" LX90; 7", 8", 10", 12", 14", 16" LX200GPS

HOW TO ORDER

1. Buy any qualifying Meade telescope from an authorized Meade dealer in the U.S.A.

2. Fax or mail a copy of your dealer's invoice, plus the completed warranty card packed with the telescope, along with your payment of $99 to Meade Instruments/Attn: Customer Service, and request the "$99 Eyepiece Offer." *Requests must include your complete shipping address and phone number.*

3. We will ship your eyepiece package to you within 30 days of our receipt of your request. Meade Instruments will pay for all shipping and insurance charges; safe arrival is guaranteed.

Other terms and conditions: Payment may be made by personal check (payable to Meade Instruments) or credit card (VISA or MasterCard). **California residents must add $7.67 sales tax, for a total payment of $106.67.** This special offer is valid only for new Meade telescopes ordered and received within the U.S.A. after 8/15/02 and is subject to change without notice. (Outside the U.S.A. contact your Meade international distributor.) There is no limit to the quantity of telescopes each person may order: each qualifying telescope is eligible to receive the special eyepiece package. Prices shown are suggested U.S. mail-order retail prices. **The SP26mm eyepiece (shown in photos above) is packed with each qualifying telescope as standard equipment.

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LX90

MEADE 8" LX90

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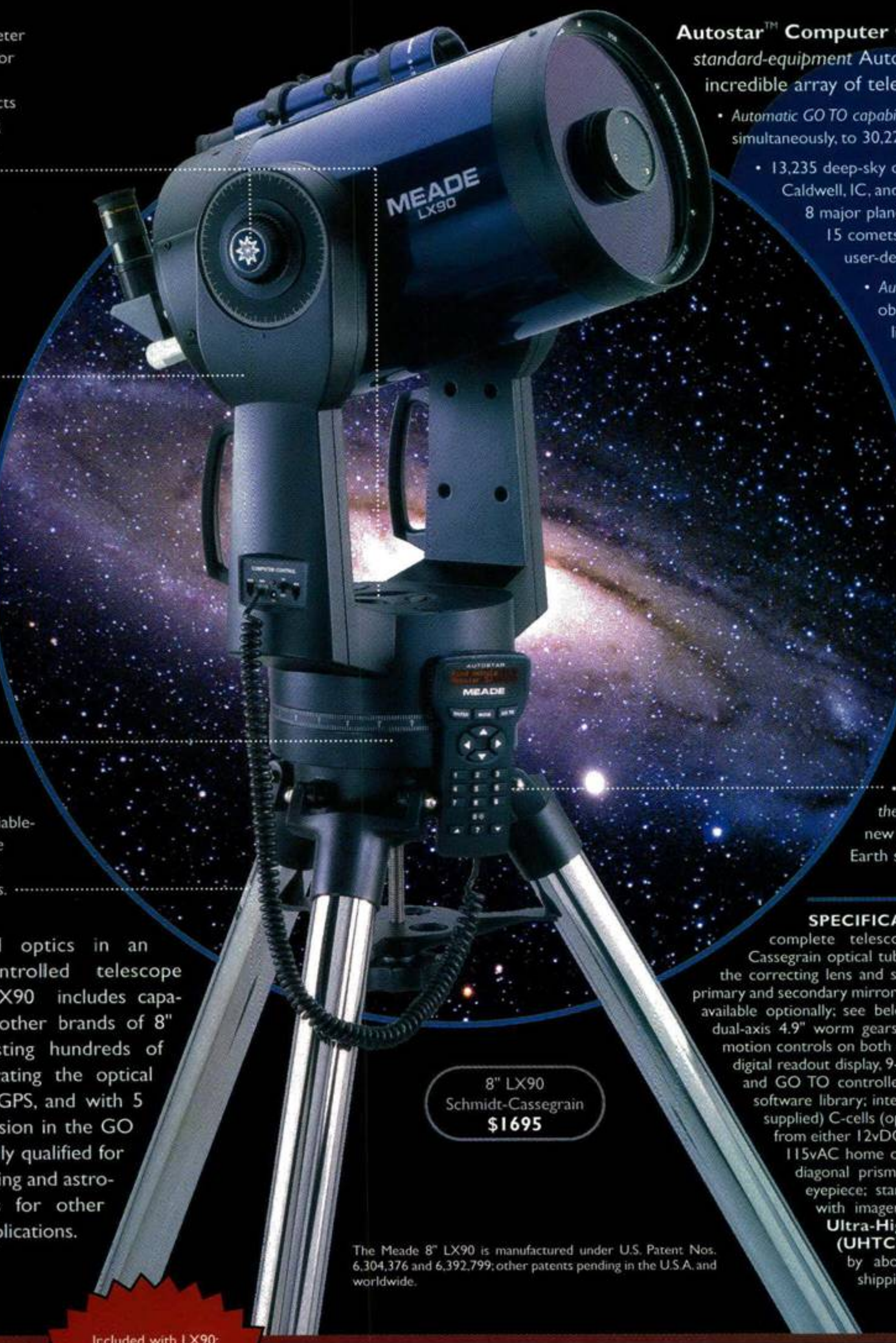

Worm gears of 4.9"-diameter on both telescope axes for smooth sidereal-rate tracking of celestial objects as well as precise guiding corrections during long-exposure imaging.

Die-cast-aluminum *double-tine* fork mount that rigidly supports the optical tube in all sky orientations.

The LX90 is powered for about 60 hours by 8 (user-supplied) C-cell batteries. Alternately, the telescope may be powered from an automobile cigarette lighter plug or from a standard 115vAC home outlet, using optionally available power cords.

Rigid chromed-steel variable-height field tripod — *the same tripod provided with Meade LX200GPS models.*

Autostar™ Computer Controller: The LX90's *standard-equipment* Autostar controller permits an incredible array of telescope features:

- *Automatic GO TO capability* at 6.5°/sec on both axes, simultaneously, to 30,223 database objects, including:
  - 13,235 deep-sky objects — the complete Messier, Caldwell, IC, and NGC catalogs; 16,888 stars; the 8 major planets; the Moon; 26 asteroids; 15 comets; 50 Earth satellites; plus 200 user-defined memory locations.
- *Automatic GO TO capability to any object of known R.A. and Declination.* Plus hundreds of special event menus, guided tours, utility functions, and telescope status options.
- *Nine selectable slew speeds:* 6.5°/sec, 3°/sec, and 1.5°/sec, as well as 128x, 64x, 16x, 8x, 2x, and 1x sidereal.
- *Control of the telescope through your personal computer.* (Requires optional #505 Connector Cable Set.)
- *Fast alignment of the telescope* using any of three alignment functions, including the Meade-proprietary Easy Align.
- *Autostar is fully upgradeable over the Internet:* add the positions of new comets, update the positions of Earth satellites, even add new software.

With diffraction-limited optics in an Autostar computer-controlled telescope system, the Meade 8" LX90 includes capabilities not available on other brands of 8" Schmidt-Cassegrains costing hundreds of dollars more. Incorporating the optical system of the 8" LX200GPS, and with 5 arc-minute pointing precision in the GO TO mode, the LX90 is fully qualified for long-exposure CCD imaging and astrophotography as well as for other advanced photo-visual applications.

8" LX90
Schmidt-Cassegrain
$1695

SPECIFICATIONS: 8" LX90 — Each complete telescope includes 8" f/10 Schmidt-Cassegrain optical tube assembly with MgF_2 coatings on the correcting lens and standard aluminum coatings on the primary and secondary mirrors (Ultra-High Transmission Coatings available optionally; see below); double-tine fork mount with dual-axis 4.9" worm gears and control panel; electric slow-motion controls on both axes; Autostar hand controller with digital readout display, 9-speed drive controls on both axes, and GO TO controller; 30,223-object onboard celestial software library; internal battery port accepts 8 (user-supplied) C-cells (optional 25 ft. cords permit powering from either 12vDC auto cigarette lighter plug or from 115vAC home outlet); 8 x 50mm viewfinder; 1.25" diagonal prism; Series 4000 Super Plössl 26mm eyepiece; standard field tripod; Autostar Suite with imager; operating instructions. **$1695. Ultra-High Transmission Coatings (UHTC) group** increases image brightness by about 20%: add **$175.** Packing & shipping in the 48 states: $95.

The Meade 8" LX90 is manufactured under U.S. Patent Nos. 6,304,376 and 6,392,799; other patents pending in the U.S.A. and worldwide.

Buy a $650 Super Plössl eyepiece set for your LX90 telescope for only $99! *See ad in this issue for details!*

Included with LX90:
Meade Autostar Suite™ including LPI™ imager
A **$149** value!
See ad in this issue for details!

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RESEARCH-GRADE ACCESSORIES

Series 4000™ Super Plössls
52° field; multi-coated

Meade 4-element Super Plössls, updated and redesigned to utilize the latest in optical glass-types, are the finest general-purpose eyepieces available. For observing hairline lunar and planetary detail, splitting close doubles, or studying tenuous nebulosity in deep-space, Meade SP's deliver unmatched contrast and image sharpness. Rubber eyeguards fold down for eyeglass wearers–a feature not available on competing brands. Multi-coated. All focal lengths through 32mm are parfocal. **Super Plössls** (SP; 4-elements; 1.25"; 52°): **6.4, 9.7, 12.4, 15, 20, 26mm** each: **$79.95** (4.54); **32mm** (52°); **40mm** (44°) each: **99.95** (5.26); **56mm** (52°; 2") **199.95** (7.02)

#1209 Zero Image-Shift Microfocuser

Identical to the Microfocuser supplied with Meade LX200GPS telescopes, but provided with a separate handbox for use with all other Meade SCT models (e.g., LX10, LX50, LX90, LX200) or for Schmidt-Cassegrains of other brands. Threads directly to the telescope's rear cell. Permits extremely precise focusing of the image during visual or photographic applications; during CCD applications maintains precise image centration on even the smallest CCD chips. Operates at four speeds, from extremely slow to fast; accepts both 2" and 1.25" eyepiece barrels. Requires 8 x AAA (user-supplied) batteries. **$249.95** (9.85)

Series 4000™ Super Wide Angle
67° field; multi-coated

For exquisite wide-angle images at low-to-medium powers, with pinpoint edge-of-field resolution. Ideal for star fields, galaxies, and other deep-space phenomena. SWA 13.8mm, 18mm, and 24.5mm are superb complements to the #140 Barlow, above. **Super Wide Angle** (SWA; 6-elements; 1.25"; 67°)–**13.8mm: $139.95** (4.54); **18mm: 149.95** (4.54); **24.5mm: 179.95** (5.26); **32mm** (2"): **239.95** (7.02); **40mm** (2"): **299.95** (7.02)

Series 4000™
Ultra Wide Angle
84° field; multi-coated

The ultimate eyepieces; extreme image sharpness over an amazing 84° field. A perfect optical match with Schmidt-Cassegrains and fast Newtonians. **Ultra Wide Angle** (UWA; 8-elements; 1.25"; 84°)– **4.7mm: $169.95** (5.26); **6.7mm: 199.95** (5.26); **8.8mm** (1.25"/2"): **239.95** (7.02); **14mm** (1.25"/2"): **299.95** (7.02)

CCD-Photo-Visual Flip-Mirror Systems

Use with any brand of CCD imager or for astrophotography with a 35mm camera. Flip mirror "down" to center the image while viewing with an eyepiece at 90°; flip mirror "up" to pass light on to CCD chip or 35mm camera film plane. Each unit includes: precision optical-flat Pyrex® mirror; 2-axis mirror-adjustment for precise image centering; extra-fine helicoid focusing of the eyepiece; extension tubes for 35mm camera (using T-Mount) or CCD imager (using either T-threads or 1.25" barrel). Threads to rear cells of all Schmidt-Cassegrain telescopes; may remain on telescope and used in place of diagonal prism for visual observing as well.

#644 Flip-Mirror System: Accepts any 1.25" eyepiece. Mirror clear aperture: 22mm. Use with CCD's up to Pictor 416XTE, ST-7, or AP1, or smaller; or visual observing with 1.25" eyepieces. **$149.95** (7.02)

#647 Flip-Mirror System: Accepts either 1.25" or 2" eyepieces. Mirror clear aperture: 40mm. Recommended for full-field 35mm astrophotography or with CCD's of any size, including all Meade Pictor Series through 1616XTE, or ST-4 through ST-10; or AP2, AP7; or for visual applications with 1.25" or 2" eyepieces. **249.95** (8.49)

#157 1.25" Adapter: Permits use of either Flip-Mirror on telescopes with 1.25" eyepiece-holders. (Requires approx. 2" additional focus travel with #644, 3" with #647.) **15.00** (3.86)

#644

#647

Series 4000™
f/3.3 CCD Focal Reducer/Field Flattener

Revolutionary 3-element Meade design permits ultrafast CCD imaging with **increased** edge-of-field resolution and color correction! Reduces CCD exposure times by up to 80%. Threads on to the rear cell of any Meade or Celestron Schmidt-Cassegrain. Converts f/10 Schmidt-Cassegrain telescopes to **f/3.3** and f/6.3 SCT's to **f/2.** Variable T-Adapter (included) allows range of f/ratios between f/3 and f/5 on f/10 SCT's and between f/1.9 and f/3.2 on f/6.3 SCT's. Use with CCD imagers of any brand and chip dimensions. Not for visual or photographic applications. Multi-coated; 41mm clear aperture. **$149.95** (5.26)

Series 4000™
f/6.3 Focal Reducer/ Field Flattener

Manufactured to exclusive Meade optical designs; threads on to any Meade or Celestron Schmidt-Cassegrain rear cell and converts f/10 scopes to f/6.3 (or f/6.3 SCT's to f/4), while significantly flattening the field. Use with SCT visual or photo accessories. Actual visual field is increased by 56%, for fine wide-field views of star fields and nebulae. In astrophotography, reduces exposure times by about 50%, while producing an actual field diameter of 1.5° at the film plane. A tremendous aid with CCD imagers in reducing image size for locating and centering images on CCD chips. 4-element optics; multi-coated; 41mm clear aperture. **$129.95** (5.26)

2x Short-Focus Barlow (1.25")

#126: Only 2.5" long, the #126 works well with any telescope accepting 1.25" eyepieces, even those with limited focus range. Maintains the high image quality of longer focal-length Barlows. Insert the #126 into star diagonal for 2x or insert star diagonal into #126 for 3x. 26mm clear aperture. Multi-coated. **$47.95** (4.54)

Series 4000™ 2x Apochromatic Barlow Lens

#140: The most advanced Barlow lens available for commercial telescopes, the Meade #140 includes 3-element, multi-coated, air-spaced optics. Doubles the power of any eyepiece with which it is used and yields images absolutely unmatched in resolution, contrast and color correction. The #140 optically complements any telescope — refractor, reflector, or Schmidt-Cassegrain. Accepts 1.25" eyepieces. Mechanical components are of machined aluminum and brass. Lens diameter is 28mm; clear aperture 26mm. **$79.95** (5.26)

Plössl 25mm Illuminated Reticle CCD Framing Ocular

Displays rectangular frames of all popular CCD chip sizes, including all Meade Pictor models; ST-4 through ST-8; AP1, AP2; and others. Shows precisely the image size and orientation that appear on CCD chip. Insert directly into telescope eyepiece-holder, or use with Flip-Mirror *(above)*. Includes 4-element coated Plössl optics; lockable spacer ring to fix focus position; rubber eyecup; variable LED illumination control; batteries. 1.25". **$129.95** (4.54)

MA12mm Illuminated Reticle Eyepiece

Excellent 3-element optical system, long eye relief, fully coated, with double crossline reticle; rubber eyecup. Wireless red LED illuminator and variable brightness control. 1.25". **Batteries included. $99.95** (3.45)

As above but with 6 ft. cord and plug for Meade telescopes with power panels, in place of wireless illuminator. **$79.95** (5.26)

Series 4000 Photo-Visual Color Filters (1.25")–Premium filters, made of purest crown optical glass, dyed in the mass. For increased contrast and resolution on the Moon and planets. Thread into the barrels of virtually all 1.25" eyepieces sold today. Fully coated.

#8 Lt. Yellow; #11 Yellow Green; #12 Yellow; #21 Orange; #23A Lt. Red; #25A Red; #38A Dark Blue; #47 Violet; #56 Lt. Green; #58 Green; #80A Blue; #82A Lt. Blue — each **$14.95** (2.73)

Set #1–4 filters: #12, #23A, #58, #80A	**49.95** (4.54)
Set #2–4 filters: #11, #25A, #47, #82A	**49.95** (4.54)
Set #3–4 filters: #8, #21, #38A, #56	**49.95** (4.54)

Series 4000 Moon Filter (#ND96): Reduces glare and irradiation during lunar observing. 13% uniform light transmission across the visual spectrum. Threads into 1.25" barrels. **$16.95** (2.73)

#905 Variable Polarizer (1.25")

For glare reduction in observing the Moon. Includes two Polarizer filters mounted in a machined cell and permits continuously variable light transmission from 5% to 25%, to compensate for varying lunar surface brightness according to the Moon's phase and the aperture of the telescope. Accepts 1.25" eyepieces. **$49.95** (5.26)

ETX® Hard Carrying Cases

For secure storage or travel with your ETX. Thick-wall construction and die-cut foam lining. Accepts telescope, optional eyepieces, erecting prism, table tripod, hand controller, etc. Includes steel latches & key.

#774 Case for ETX-90 models: **99.95** (8.58)
#776 Case for ETX-105 models: **99.95** (8.58)
#775 for ETX-125 models: **149.95** (13.38)

Electric Focusers for ETX®

Meade-engineered for smooth, rapid focusing with ETX-90, -105, or -125. Four-speed operation from coarse to microfine. Standard-equipment hand controller accepts one 9v. (user-supplied) battery and focuses all ETX telescopes. Or focus through the telescope's Electronic Controller (EC) or through Autostar.

#1244 Electric Focuser for all ETX-90 and ETX-105 models: **$119.95** (6.85)

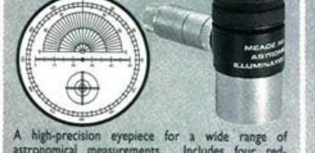
#1247 Electric Focuser for ETX-125 models: **$119.95** (6.85)

World's Most Advanced Illuminated Reticle Eyepiece

Series 4000 Plössl 9mm, with rubber eyecup and micrometric X-Y positioning of the reticle within the field. Greatly facilitates locking on the guide star. Sharp high-power imaging, excellent eye relief. Wireless red LED illuminator with adjustable brightness control. Multi-coated optics. **Internal batteries included.** Bullseye reticle. 1.25". **$149.95** (6.14)

Series 4000 Plössl 9mm—Same as above but with 6 ft. cord and plug for Meade LX3, LX5, LX6, LX100, LX200, and APO power panels, in place of wireless illuminator. **$129.95** (5.26)

MA12mm Illuminated Reticle Astrometric Eyepiece



A high-precision eyepiece for a wide range of astronomical measurements. Includes four red-illuminated, laser-etched scales for measuring double star angular separations, position angles, planetary diameters, and lunar crater diameters, and for long-exposure photo-guiding. Modified Achromatic 3-element coated optics; diopter adjustment; rubber eyecup; variable LED illumination control; batteries. 1.25". **$119.95** (4.26)

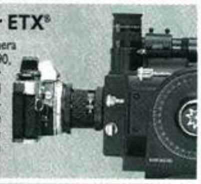
Series 4000™ 8mm – 24mm Zoom Eyepiece

The finest zoom eyepiece available. High-resolution 7-element multi-coated optics, with 55° field at 8mm. Graduated scale in 1mm units indicates exact focal length in use. High-eyepoint yields comfortable observing even with eyeglasses. Internal zoom lenses move on the smoothest, most precisely-machined tracks yet developed for zoom optics. Performance is fully consistent with the finest fixed-focal length eyepieces. Threaded for filters; rubber eyecup; 1.25". **$219.95** (6.38)

#825 8 x 25mm Right-Angle Viewfinder for ETX-90

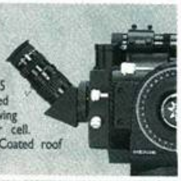
Replaces standard-equipment finder on ETX-90, using the same bracket. Wide-angle, achromatic, coated optics; actual field 7.5°. Precise helicoid focusing. **$49.95** (4.26)

#64 T-Adapter for ETX®



Rigidly couples any 35mm camera with removable lens to ETX-90, ETX-105, or ETX-125 for lunar, planetary, or terrestrial photography. Includes extension tube for longer effective focal length, if desired. Use with T-Mount for your 35mm camera. **$34.95** (3.86)

#932 45° Erecting Prism for ETX®



For terrestrial observing with any ETX-90, ETX-105, or ETX-125 model. Yields correctly oriented image and convenient 45° observing angle. Threads to ETX rear cell. Accepts any 1.25" eyepieces. Coated roof prism optics. **$49.95** (3.86)

Dew Shields for ETX®

Threads into the front lens-cell and effectively inhibits the formation of dew on the lens surface.

#670 for ETX-60/70	**19.95**
#673 for ETX-90	**24.95**
#675 for ETX-105	**27.95**
#678 for ETX-125	**29.95**

HOW TO ORDER

Prices shown are suggested U.S.A. mail-order retail prices and do not include any applicable sales taxes. Suggested shipping and handling charges to the 48 states by U.P.S. or U.S. Mail shown in ( ) next to each price. **The following national mail-order dealers carry Meade accessories in-stock for immediate shipment:**

ASTRONOMICS, Norman, OK.
Orders: 800-422-7876; Info.: 405-364-0858.

OCEANSIDE PHOTO & TELESCOPE, Oceanside, CA.
Orders & Information: 800-483-6287.

ANACORTES TELESCOPE, Anacortes, WA.
Orders & Information: 800-850-2001.

RIVERS CAMERA, Dover, NH.
Orders & Information: 800-245-7963.

FOCUS CAMERA, Brooklyn, NY.
Orders: 800-221-0828; Info.: 718-436-6262.

SHUTAN CAMERA & VIDEO, Chicago, IL.
Orders & Info.: 800-621-2248; IL: 847-367-4600.

WOODLAND HILLS CAMERA & TELESCOPE, Woodland Hills, CA. Orders: 888-427-8766; Info.: 818-347-2270.

EFSTONSCIENCE, Toronto, Ontario, Canada
Orders & Information: 416-787-4581.

KHAN SCOPE CENTRE, Toronto, Ontario, Canada
Orders & Information: 416-783-4140.

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MEADE®

LXD55

Choose from nine Meade Schmidt-Newtonians, Schmidt-Cassegrain, and Achromatic Refractors, each with Autostar® or Electronic Controller — from $579, *complete!*

Observe ***hundreds*** of galaxies, nebulae, and star clusters of all types ***your very first night out,*** and hundreds more the next night out, simply by pressing the Autostar GO TO pushbutton. Watch as the telescope fast-slews at 4.5°/second, locating each object — from the brightest to the most obscure — and placing it automatically, unerringly, and precisely in the telescopic field. Or choose one of the new EC-models with dual-axis Electronic Controller, telescopes upgradable at any time in the future to full GO TO status just by adding the Autostar hand controller.

Autostar-equipped models:

6" Model **SN-6** Schmidt-Newtonian	**$695**
8" Model **SN-8** Schmidt-Newtonian	**839**
10" Model **SN-10** Schmidt-Newtonian	**995**
8" Model **SC-8** Schmidt-Cassegrain	**1195**
5" Model **AR-5** Achromatic Refractor	**695**
6" Model **AR-6** Achromatic Refractor	**895**

Electronic Controller-equipped models:

6" Model **SN-6EC** Schmidt-Newtonian	**579**
8" Model **SN-8EC** Schmidt-Newtonian	**699**
5" Model **AR-5EC** Achromatic Refractor	**579**
#497 Autostar Controller, for EC-models	**149**

MEADE
LXD55

Meade Model SN-8 8" f/4 Schmidt-Newtonian Telescope with standard-equipment Autostar Control System.

(below, left to right) 8" Model SC-8 Schmidt-Cassegrain; 5" Model AR-5 and 6" Model AR-6 Achromatic Refractors.

Meade Ultra-High Transmission Coatings (UHTC) Group: Available optionally at the time of telescope purchase, the UHTC group increases image brightness by about 20% over the visible spectrum.
SN-6, SN-EC – $85;
SN-8, SN-8EC – $125;
SN-10 – $150, SC-8 – $175

Packing & shipping charges in the 48 states:
SN-6, SN-6EC – $75;
SN-8, SN-8EC – $85;
SN-10 – $95;
SC-8 – $85;
AR-5, AR-5EC – $85;
AR-6 – $95

SUPER PLÖSSL

Buy a $650 Super Plössl eyepiece set for your LXD55 telescope for only $99! *See ad in this issue for details!*

New 2003 Meade General Catalog!

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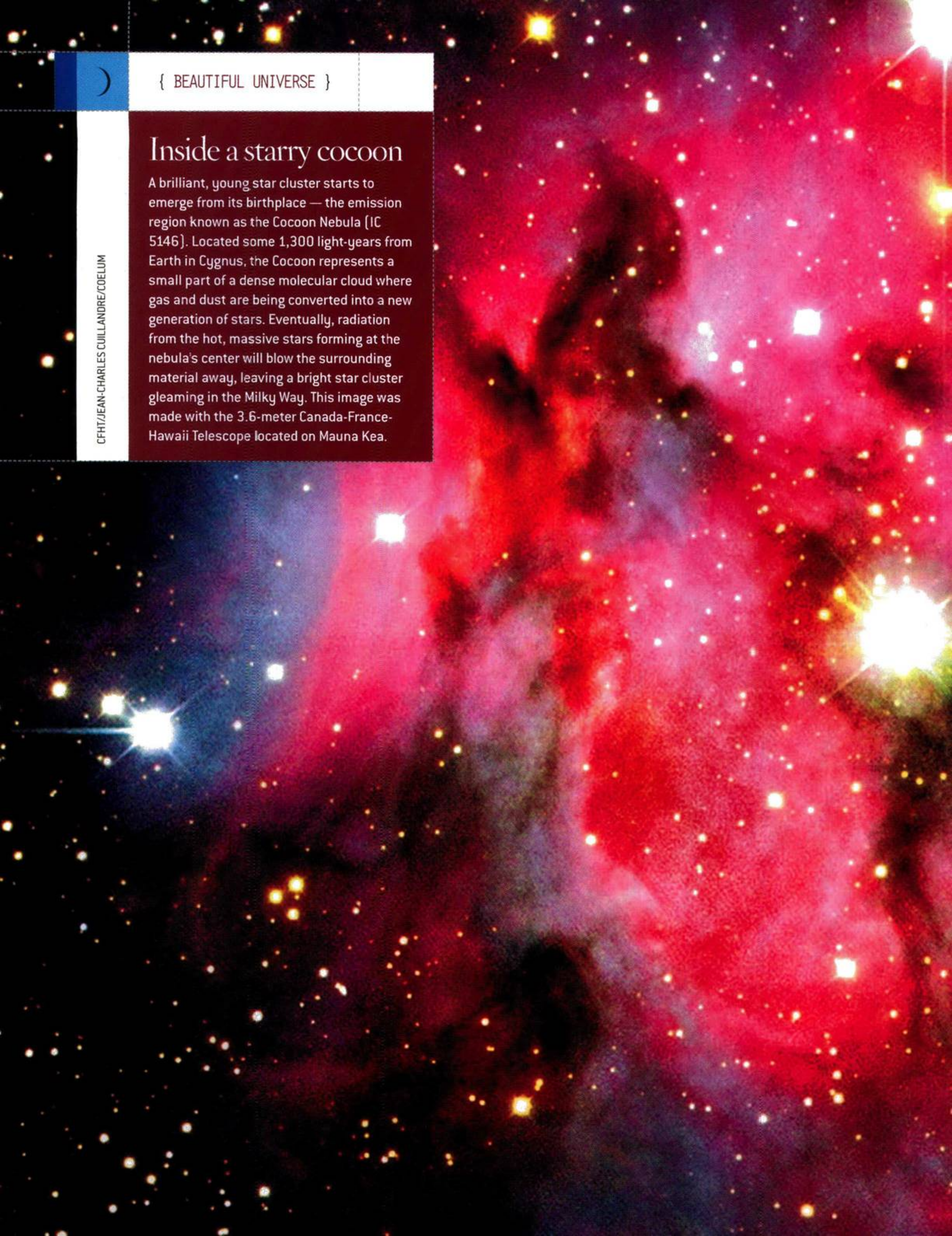
Inside a starry cocoon

A brilliant, young star cluster starts to emerge from its birthplace — the emission region known as the Cocoon Nebula (IC 5146). Located some 1,300 light-years from Earth in Cygnus, the Cocoon represents a small part of a dense molecular cloud where gas and dust are being converted into a new generation of stars. Eventually, radiation from the hot, massive stars forming at the nebula's center will blow the surrounding material away, leaving a bright star cluster gleaming in the Milky Way. This image was made with the 3.6-meter Canada-France-Hawaii Telescope located on Mauna Kea.



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TELESCOPES & BINOCULARS

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TELESCOPES

New! Orion SkyQuest™ XT IntelliScopes™

Enjoy Computerized Pointing to 14,000 Celestial Objects with Pushbutton Ease!

SkyQuest XT6 IntelliScope

The new-generation XT6 makes a superb starter scope even without the optional IntelliScope Controller. Add the Controller and the scope literally finds objects for you! Features a 150mm parabolic mirror (1200mm f.l., f/8.0) and new, streamlined base with springless CorrecTension. Also 1.25" aluminum focuser, 6x30 finder scope, two Sirius Plössl eyepieces, and more.

Only **$359**
(IntelliScope Controller sold separately)

SkyQuest XT8 IntelliScope

The world's best-selling 8" Dobsonian, the XT8, boasts newly enhanced features, including IntelliScope object-location capability. Features a 203mm parabolic primary mirror (1200mm f.l., f/5.9) that reaches deep into space for jaw-dropping images of the planets, nebulas, clusters, and galaxies. Features 2" aluminum focuser, 9x50 finder scope, springless CorrecTension, two Sirius Plössl eyepieces, and more.

Only **$479**
(IntelliScope Controller sold separately)

SkyQuest XT10 IntelliScope

The XT10 takes another giant leap forward. With its dazzling optics, a contemporary new design, and IntelliScope computerized pointing capability, it's a scope that will thrill for a lifetime. Features a 254mm Pyrex parabolic mirror (1200mm f.l., f/4.7), 2" aluminum focuser, 9x50 finder scope, springless CorrecTension, two Sirius Plössl eyepieces, and more.

Only **$649**
(IntelliScope Controller sold separately)

IntelliScope™ Controller
(Optional)

Locate and view any of more than 14,000 celestial objects in seconds! With this optional Controller, you just select an object to view, press Enter, then move the telescope in the direction of the guide arrows on the backlit LCD screen. In seconds, the object will be smack-dab in the telescope's field of view. Easy!

Only **$149**

SkyView™ Pro Telescopes

Special Offer!
Order now and receive a FREE TrueTrack™ single-axis drive or save $70 off a TrueTrack™ dual-axis drive.

SkyView Pro 6LT

For anyone interested in extra magnifying power for viewing lunar terrain, Jupiter's bands, Saturn's rings, or double stars, the 6LT will get the job done. The 150mm, 1200mm focal length (f/8) parabolic primary mirror delivers 60% greater magnification than you get from shorter models using the same eyepiece. Includes 6x30 finder scope, two 1.25" Sirius Plössl eyepieces (25mm and 10mm), collimation cap and dust-cap.

SVP 6LT & FREE drive
$469

SkyView Pro 8

Finally, a telescope that gives views that will blow you away without blowing your budget! A full 8" (203mm, f/4.9) parabolic primary mirror, which gathers 73% more light than a 6". The tube features a 2" aluminum rack-and-pinion focuser and a sturdy 4-vane holder. Includes 6x30 finder scope, two 1.25" Sirius Plössl eyepieces (25mm and 10mm), collimation cap and dust-cap.

SVP 8 & FREE drive
$549

SkyView Pro 120

Love refractors? We've combined our 120mm achromatic refractor with our super-sturdy SkyView Pro mount. The big fully multi-coated 120mm (f/8.3) objective lens and 2" focuser will give you jaw-dropping views of the skies. Includes 6x30 finder scope, two 1.25" Sirius Plössl eyepieces (25mm and 10mm), 90° star diagonal, collimation tool and dust-cap.

SVP 120 & FREE drive
$549

SkyView Pro 127

Given the popularity of our 127mm Mak, it's only natural that we offer it with the best new mid-sized equatorial mount in the market, the SkyView Pro. The 5" Maksutov-Cassegrain optics pull in plenty of light for great views of deep-sky gems. And you can't beat its long focal length of 1540mm (f/12.1) for high-magnification study of the Moon and planets. Includes 6x30 finder scope, two 1.25" Sirius Plössl eyepieces, (25mm and 10mm), 90° mirror star diagonal, optical tube carry case and dust-cap.

SVP 127 & FREE drive **$649**

Orion 80mm ED Refractor

Finally, a premium "apo" you can actually afford! With a focal length of 600mm (f/7.5), the "ED80" is wonderfully suited for visual applications as well as for film or CCD imaging. Fully multi-coated 80mm objective doublet, with one element made from Extra-Low Dispersion, or "ED" glass for superior color correction. Backlash-free, 2" Crayford-style focuser. Just 24" long. Tube assembly only, without accessories.

Only **$429**

Atlas 10 Reflector

This celestial cyclops will enchant for a lifetime. Our biggest optical tube (254mm, f/4.7) on our beefiest mount will give you incredible images. Dual internal drives built in to the mount. Includes 9x50 finder scope, polar alignment scope, 25mm (48x) and 10mm (120x) 1.25" Sirius Plössl eyepieces, 2" collimatable focuser w/ 1.25" adapter, prime-focus camera adapter with T-thread, multi-speed hand controller, collimation cap and dust cap.

$1,299
Also available:
Atlas 8, $1,099

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100% Satisfaction
for any reason, just return it in new condition within 30 days after delivery for a prompt refund.
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telescope.com

ACCESSORIES

New!

Orion Dynamo™ 12-Volt DC Rechargeable Power Station

Power your motor-driven telescope and electronic accessories with this versatile, portable 12V DC power supply. The Dynamo is a sealed, fully rechargeable, 7-amp-hour battery with dual 12V DC "cigarette lighter" output ports (10 amps max.), plus 3V, 6V, and 9V DC male pin jack outputs (1 amp max.). With built-in flashlight with red lens cover and a bright, 55-watt hinged spotlight. Includes 110V AC and DC charging adapters and shoulder strap.

$56.95

New!

Orion V-Block™ Anti-Fringing Filter

The Orion V-Block filter effectively removes distracting color halos from around bright objects, greatly improving image sharpness, color, contract, and resolution. Works well with achromatic refractors of any aperture or focal length. Threads into eyepieces, diagonals, and barlow lenses that accept 1.25" or 2" filters.

1.25" V-Block Filter	**$69.95**
2" V-Block Filter	**$89.95**

SkyView™ Pro EQ Pier Mount

New!

Our SkyView Pro equatorial head is now available on a beefy pier pedestal. In our tests, the pier edged out the tripod version of the SVP mount for stability, and that's no small feat! Credit the 4"-diameter steel pillar and the girder-like, 16.5" steel strut legs. The legs clamp on rigidly with just three bolts (total), for quick setup and take-down. Removable castors let you roll the mount on hard surfaces. Large leveling bolts on the legs provide a firm, level stance. Height at top of EQ head, 4' 1". Optional 16" Pier Extension available. Weighs 73 lbs.

$449

Steel Pier Pedestal
(Only)

Includes adapter plate for SkyView Pro equatorial head. Height, 34-3/4". Weighs 47 lbs.

$249

Orion Aluminum Focus Wheels

New!

Replace those standard plastic focus knobs with these stylish aluminum wheels, complete with rubber grip. They fit most Orion telescopes and many other competitors' scopes (see telescope.com or call for list). Set of two wheels with mounting screws.

$19.95

Shorty™ 2x Barlow Lens

This compact barlow is just 2-7/8" long, about half the length of a regular barlow, for greater convenience and versatility. Fits all 1.25" telescope eyepieces. Features a multi-coated, baffled achromatic lens system.

$39.95

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Special visco-elastic material reduces vibrations from wind and other sources. Put under tripod legs for steady images. Ideal for both visual astronomy and astrophotography. Sold in sets of three.

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Creativity welcome

I thoroughly enjoyed "Great balls of fire" by Marcia Bartusiak (November 2003) about globular cluster research, but I'm saddened by some of the commentary. Bartusiak notes astronomer François Schweizer's concern about voicing his view on the age of globular clusters vis-à-vis galaxy formation; Schweizer is quoted as saying: "I knew the suggestion might ruin my career."

Although Schweizer's comment may have been a bit jocular, alternative discourse often does result in rebuke. The history of science is rife with examples. As a lawyer and amateur astronomer, I have found that we lawyers frequently treat each other with greater civility than some in the scientific community!

Those who have the courage to challenge certain norms deserve our applause. Our understanding of cosmology should not be stifled by politics — or any other paradigm.

— **ANTHONY D. ZINNANTI,** SAUGUS, CALIFORNIA

GLOBULAR CLUSTER G1 shines with the light of more than 300,000 ancient stars. M. RICH, K. MIGHELL, J. D. NEILL (COLUMBIA UNIV.); W. FREEDMAN (CARNEGIE OBS.); AND NASA

Opposites repel?

Perhaps Mother Nature has fooled us once again, and the missing energy [discussed in "Absurd universe" (November 2003)] will be discovered in the yet to be confirmed anti-particle of graviton. And, in nature's greatest irony yet, this complementary pair will be mutually repellent instead of attractive, offering an explanation for the slowing of the speed of light. Fascinating.

— **HAL BYRON BECKER,** PHOENIX, ARIZONA

Giving credit

I recently read Ray Jayawardhana's interesting article on the Orion Nebula, "Style & substance" (October 2003). It was nice that he pointed out the discoverers of the various objects. Unfortunately, there's an error in one of the people mentioned. The K in the KL nebula is for Doug Kleinmann, Susan Kleinmann's husband. Doug and Susan were both students of Frank Low at Rice University. Doug left astronomy in the 1970s after several years at the Harvard-Smithsonian Center for Astrophysics.

— **PROF. ERIC BECKLIN,** UCLA

Shuttle safety revisited

I'm writing in response to "Safety first," a letter printed in the October 2003 issue. I work for NASA, and I agree that safety should be our first priority — and it is.

An escape pod has been looked at in the past, but it cannot help in all cases, as Mr. Schreiner suggested. Yes, it most likely would have helped the Challenger crew in 1986 because the shuttle was only 73 seconds into flight. However, in the case of Columbia, it would have been impossible for an escape pod to save the crew.

Think about this. You're traveling more than 12,000 mph at over 200,000 feet in altitude. Remember the horrifying pictures of the shuttle breaking up? I know they're forever ingrained in my mind. Well, guess what would have happened to an escape pod? The same thing. Unfortunately, once the orbiter started breaking up, there was no hope. I realized this when I was in Texas working on the recovery effort; we found pieces of the grand orbiter that were no bigger than a quarter!

It was a sad time and always will be in my heart. As an astronaut-hopeful, however, I know the risks involved in space flight. Nothing is foolproof. Astronauts are well aware of the risks, but they are doing what they love to help further science and technology for all of us in this great country and around the world.

We need to get back to flying the shuttle soon. It's amazing to see the efforts here at NASA to fly again. We will fly soon, and it will be as safe as humanly possible.

— **KIM GUODACE,** PALM BAY, FLORIDA

Corrections

The lunar image on page 87 in "Simple telescopic shooting" (October 2003) was taken by H. J. P. Arnold.

For more information on the Coronado MaxScope 70, which was featured in our "Super scope buyer's guide" (November 2003), contact:

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— ***ASTRONOMY* EDITORS**

We welcome your comments. Send letters to Astronomy Letters, P. O. Box 1612, Waukesha, WI 53187; e-mail to letters@astronomy.com. Please include your name, city, state, and country. Letters may be edited for space and clarity.

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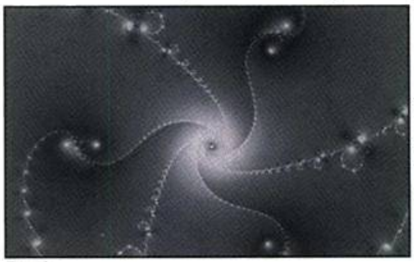

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{ BOB BERMAN'S STRANGE UNIVERSE }

BY BOB BERMAN

Nothing *is* absolute

Are the space shuttles safe? Is a refractor better than a reflector? No clear-cut answers exist to these and countless other questions, so it's refreshing to have *some* absolutes we can count on. One take-it-to-the-bank certainty in this uncertain universe comes to mind readily during this cold season: absolute zero.

Heat is simply the motion of atoms: Something feels hot because you sense the frenzied movement of those little critters. At 98.6° Fahrenheit, all your body's atoms are jiggling at about 1,000 miles per hour. They'll jiggle even faster when you run a fever during your next winter flu. They'll never stop, even after you die. Even at the coldest place on Earth (Antarctica, where a frosty –129° F registered on July 21, 1983), there's still plenty of atomic motion. Atoms stop moving only at –459.67° F. Because nothing can move any slower than "stopped," this is indeed the coldest temperature possible — absolute zero.

Until the mid-1960s, most astronomers thought that far away from any stars, thermometers would register absolute zero throughout the cosmos. We now know that the heat of the Big Bang, cooled by expansion, produces a 5° F warmth, or 2.73 on the kelvin scale.

The solar system's coldest place is Triton, Neptune's major moon. Colder still is an expanding, dusty gas cloud 5,000 light-years away, the Boomerang Nebula in the constellation Centaurus. First measured in 1997 and confirmed last spring, it's an astronomical icebox at 1° Celsius above absolute zero. But even that is no longer the universe's ultimate Minnesota.

> The material wasn't solid, liquid, gas, or plasma. It had become the Bose-Einstein condensate, a new kind of reality.

The coldest place in the universe? It's found in research laboratories right here on Earth where temperatures less than a billionth of a degree above absolute zero were created during the past few months. This technological dive to ever-chillier temperatures takes us into an Alice-in-Wonderland realm of bizarre conditions.

As things cool, they lose all resistance to electrical flow, creating superconductivity. Strange magnetic properties, such as the Meissner effect — which makes magnets levitate like Houdini's assistants — also arise. Then there's superfluidity, where liquid helium flows *up* the sides of its container, escaping like some resourceful rat by scampering up and out. But to find the weirdest thing that happens as materials approach absolute zero requires a quick rewind to 1924.

Back then, Albert Einstein received a letter from Indian physicist Satyendra Nath Bose. This started a collaboration that led to their prediction that at absolute zero, a new, totally unknown state of matter would appear. Scientists quickly dubbed this odd consequence of quantum theory the Bose-Einstein condensate.

Just a few years earlier, Werner Heisenberg had created his uncertainty principle, which sets strange limits on what we can know about small particles. We cannot, for example, precisely figure out an electron's motion and its position. Pin down one, and the other instantly becomes fuzzy.

But isn't there an escape clause? What if you chilled those particles to absolute zero — where all motion stops? Then, you'd know it's motion (zero), and you'd see it right in front of you. *Voila*! Position and momentum both revealed. So, a cold enough freezer should be able to fool quantum laws. Bose and Einstein said: No way. They believed nature would still manage to disguise itself by creating a new state of existence.

Just eight years ago, researchers at the National Institute of Science and Technology cooled two thousand atoms to twenty billionths of a degree above absolute zero. Like magic, the atoms merged into a super-atom never before encountered. We still couldn't know the atoms' separate qualities because their individualities had vanished into a single quantum state, a new kind of reality. The material wasn't solid, liquid, gas, or plasma. It had become the Bose-Einstein condensate.

The Bose-Einstein condensate has unimaginable technological applications. We know its super-high optical density brakes light to slower-than-freeway-traffic speeds, and it can freeze light entirely under certain conditions. Development of such technology is held back only because reaching those ultra-cold temperatures is still so demanding.

Yes, most of the universe, like much of the country right now, is freezing cold. But stay tuned: Pockets of greater cold are about to change our lives for the better. ■

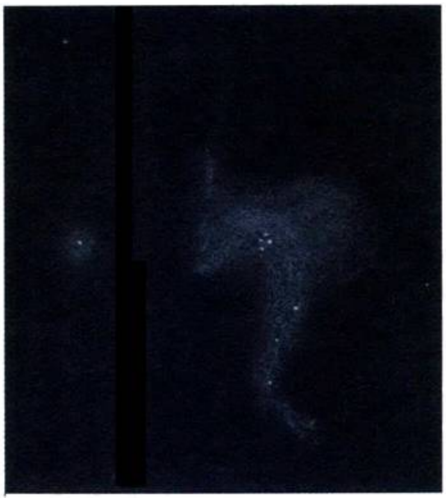
The Orion Nebula

Skygazing in Arctic temperatures and deep snow drifts tests your survival skills. I live in a heavily wooded residential area in northern Massachusetts. Because of the trees surrounding my property, I have to move my telescope from one part of the backyard to another to find access to open areas near the horizon. Winter compounds the problem. After the season's first snowfall, I shovel out a few key observing sites (just big enough for me and a portable telescope). One of those little havens gets special attention, though, because it allows me a relatively open view of the southern sky — the early evening location of Orion and its telescopic treasures.

Orion rewards us for braving the cold winter night. Of its treasures, none is as dazzling as the Orion Nebula (M42). Ask an amateur astronomer to identify her or his favorite deep-sky objects, and the Orion Nebula is almost sure to appear near the top of the list. What accounts for this popularity? The Orion Nebula is bright and easy to locate — an ideal target for the novice; it's accessible to a wide range of optical instruments, from standard binoculars to the largest telescopes; and it's situated just 5° from the celestial equator, allowing it to be viewed from virtually anywhere on Earth. These factors, plus plenty more, make the Orion Nebula a magnificent sight!

My favorite things to read — after *Astronomy* magazine — are late nineteenth and early twentieth century astronomical books. In his 1906 guide *Pleasures of the Telescope*, Garrett Serviss wrote of the Orion Nebula: *If we do not gaze at it long and wistfully, and return to it many times with unflagging interest, we may be certain that there is not the making of an astronomer in us.*

Three years later, in his book *In Starland With a Three-inch Telescope*, William Tyler Olcott wrote: *Words fail to describe the great nebula. Its glories must be seen to be appreciated.*



THIS ORION NEBULA SKETCH shows the nebula as it appears through a small telescope (60mm refractor) at 90x. GLENN CHAPLE

On a clear, moonless evening, look for Orion's distinctive belt and the row of fainter stars (his "sword") suspended beneath it. The middle star in the sword tends to look fuzzier than the others because it isn't a star at all. It's the Orion Nebula. Binoculars clearly reveal this misty patch of light for what it is.

Begin your telescopic exploration of the Orion Nebula with low power (15x to 30x). What you see through the eyepiece depends on the size telescope you're using, the darkness of the night sky, and your observing experience. Obviously, the bigger the scope and darker the skies, the more detail you'll see. But don't worry if you own a small telescope; the Orion Nebula looms large and bright even in the smallest instrument. Your observing experience, however, is another matter.

In 1970, when I viewed the Orion Nebula with an untrained eye and a 3-inch reflecting telescope, I saw a small oval glow around a tiny cluster of stars. Years later with the same scope and similar sky conditions, my experienced eye perceived not only that same glow but wreaths of nebulosity streaming outward from it like eagle's wings. For the first time, I glimpsed M43 — a detached part of the Orion Nebula that surrounds a star slightly north of the Orion Nebula.

Seen through a large telescope, the Orion Nebula is spellbinding. A greenish hue becomes evident, and the nebulosity has a mottled appearance. The nebula covers an area a full degree across — twice the apparent diameter of the Full Moon.

When you look into the heart of the Orion Nebula, you discover its most delicate treasure: the beautiful multiple star Theta^1 (θ^1) Orionis ("Trapezium"). Its four brightest stars, arranged like a tiny baseball diamond, shine at eighth and ninth magnitudes. These stars were born from the gases in the surrounding nebula. Higher magnifications (75x to 100x) will give you a good view of the Trapezium. Here, you have the finest multiple star in the night sky immersed in what many consider the grandest nebula.

Now, ponder the size of this grand nebula. You're looking at a colossal gas cloud 1,500 light-years away and 30 light-years across — a diameter equal to seven times the distance from our solar system to the nearest star, Alpha (α) Centauri.

So, go pay homage to the Orion Nebula. Let its beauty excite your visual senses and its mystery stir your imagination.

Next month: Get your telescopes ready, and put on those track shoes. We're running two astronomical marathons.

BY WILLIAM SCHOMAKER

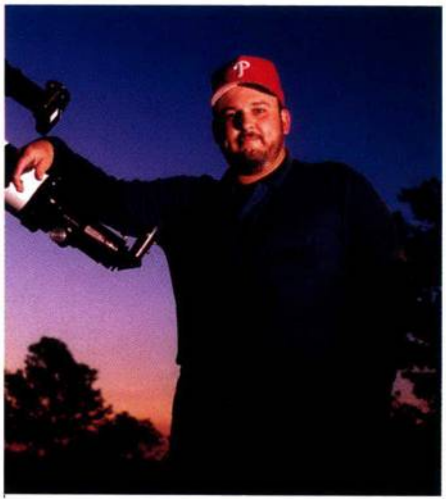
Jerry Lodriguss

No, he's not a government spy or a lowlife two-timer. But his adventures often do involve nighttime rendezvous, cameras, and the occasional firearm.

By day, Lodriguss captures sports superstars in their shinier moments — as the 16-year veteran, award-winning sports staff photographer for the *Philadelphia Inquirer*.

By night, the proud descendant of Cajuns and Creoles from the bayous of southern Louisiana slinks into the darkness, fueled by a 30-year obsession and armed with hundreds of pounds of equipment, to capture hall-of-fame shots of the universe's usual suspects.

Lodriguss's images of nebulae and galaxies have been prominently featured in books and magazines around the globe. He's the author of a new book, *Photoshop for Astrophotographers*, a guide to digital correction and enhancement techniques for astrophotos. Explore Lodriguss's world of sports and astronomical imagery, sage advice, and hilarious anecdotes (don't miss the one about the shotgun and a desert alien) at www.astropix.com.



JERRY LODRIGUSS photographs superstar athletes on the field and hall-of-fame deep-sky objects in space. JERRY LODRIGUSS

How does a three-time Pulitzer prize-nominated sports photographer get into astrophotography?

Actually, I bought my first camera to take pictures through my telescope. Because it was cloudy so often in New Orleans, I started taking pictures of daytime subjects.

I had always liked sports and discovered that I had the hand-eye coordination required to follow-focus sports action — a difficult skill. Later, I realized that not only could I get into sporting events for free as a press photographer, I also could get paid for it. It seemed like a nice hustle to me, so I turned it into a full-time job.

My skills as a sports photographer matured more quickly than my skills as an astrophotographer. When I first got into astrophotography, there were very few resources to learn from, so naturally, I learned everything the hard way — through trial and error, but mostly error. A friend and I once tried to do long-exposure, deep-sky astrophotography with his 12-inch f/8 Newtonian while guiding with an 8-inch Schmidt-Cassegrain piggybacked on top in wooden rings and held in place with twine. I've come a long way since then.

What does your typical equipment setup look like when you're on location?

It's quite a production with eleven cases and bags of essential equipment, plus other miscellaneous stuff.

There's a case for my Astro-Physics 130 EDT f/8 refractor; a case for my Losmandy GM 100EQ mount; a case for my CECO cinema tripod; a case for the counterweights; one for the telescope eyepieces; a case for photographic accessories; a 75 amp-hour, deep cycle marine battery case; a bag for charts and notes; a bag for winter clothes; a case for camera lenses and camera bodies (4 bodies, 6 lenses); and a case for telescope accessories. And then there's food, water, CD player, CDs, a chair . . . I keep a complete list of essentials on my web site in case anyone's interested.

Of all the remote locations you've visited in search of the perfect exposure, do you have a favorite?

My favorite astrophotography site is on top of a mountain called Massai Point in the Chiricahua National Monument in the southeastern corner of Arizona. It is one of the darkest locations on the planet. It has a paved parking lot on top of the mountain at 6,800 feet, and its location at 32° north latitude allows photography of some southern objects that are very difficult to see from the rest of the United States.

How about some advice for our budding astro-shutterbugs out there?

Be a voracious reader. Read [Terrence] Dickinson, [Michael] Covington, [Robert] Reeves, and [Brad]Wallis and [Robert] Provin. Join a local astronomy club and pick the brains of the resident astrophotographer — there's one in every club. Do not buy a telescope for astrophotography until you have researched it thoroughly.

Begin at the beginning. Do the simple stuff first, like star trails on a fixed tripod. Then, progress to piggyback photography with short focal length camera lenses. Save the long-exposure, prime-focus, deep-sky astrophotography for when you're ready. ■

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ETX 90AT 1250mm f/13.8 w/UHTC	$645
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ETX 105AT w/UHTC	$874
ETX 125AT 1900mm f/15	$995
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THE PLEIADES ARE CAUGHT in a three-way slow-motion smashup, say astronomers at the National Optical Astronomy Observatory. A study shows the cluster's stars are colliding with two separate interstellar dust clouds.

news 02

Read all about it: The most active star-forming region known, giant solar flares, making telescopes smarter, and the nearest galaxy to the Milky Way.

HUBBLE HERITAGE IMAGE

Born in a rough neighborhood

Eight thousand light-years from Earth in the southern sky lies a dense cloud of dust and gas called the Carina Nebula. It is bright enough to be visible to the naked eye. One small portion of the cloud bears the name Eta Carinae Nebula — after its most famous object: an unstable variable star that's one of astronomers' best candidates for an upcoming supernova explosion.

In July 2002, the Hubble Space Telescope's Wide Field Planetary Camera 2 took this deep image of part of the Carina Nebula, filtering the view to identify emission from oxygen, hydrogen, and sulfur, common elements in star-forming clouds.

Astronomers Stefano Casertano (STScI) and Jay Frogel (Ohio State University) were studying how "winds" from stars that are shedding their outer layers, plus high-energy radiation, are pushing on the interstellar medium and shaping it into bright tendrils and dark filaments.

Turbulence in interstellar clouds stirs elements together, mixing colder gas with hotter. The darker portions of the image show where clouds of cool dust stand in front of the nebula's hotter gas.

Shock waves from the turbulence will likely trigger the formation of stars and planetary systems, which may begin to coalesce in the dense regions of the nebula. Out of just such a process grew the Sun and solar system, some 4.6 billion years ago. — **ROBERT BURNHAM**

26 **Taking the slow boat to the Moon**
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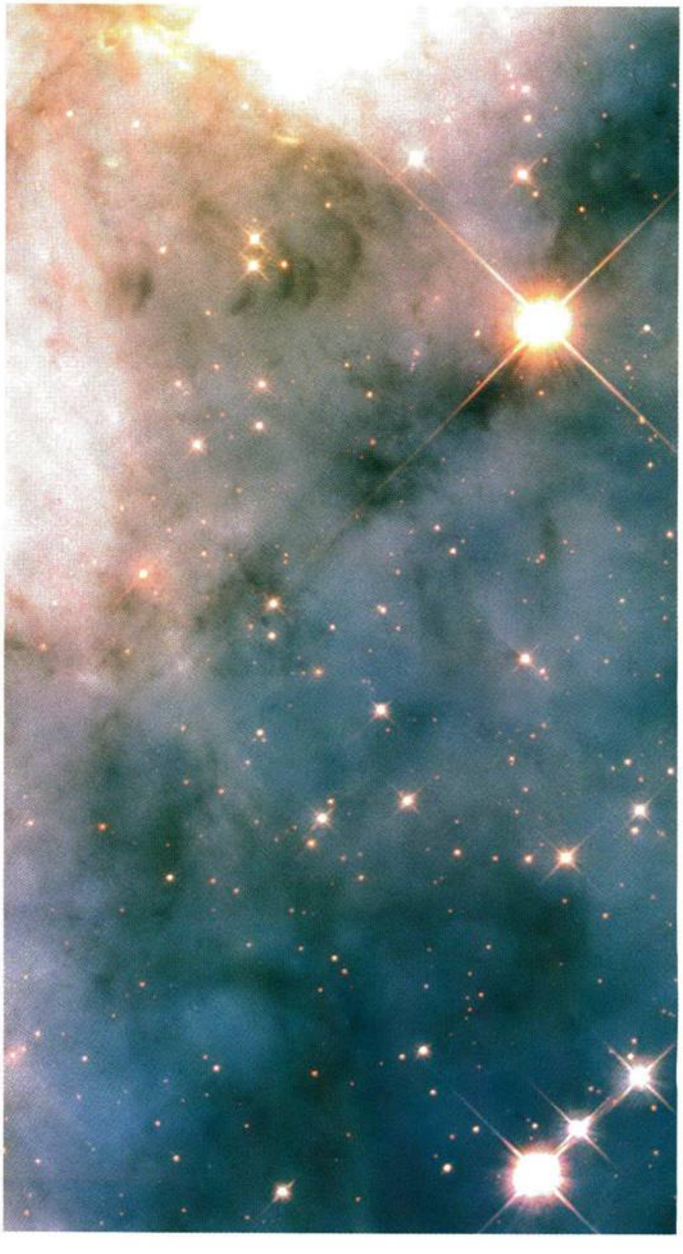

ROILING CLOUDS in the Carina Nebula show likely places where new stars (and planetary systems) may form. STScI AND HUBBLE HERITAGE TEAM

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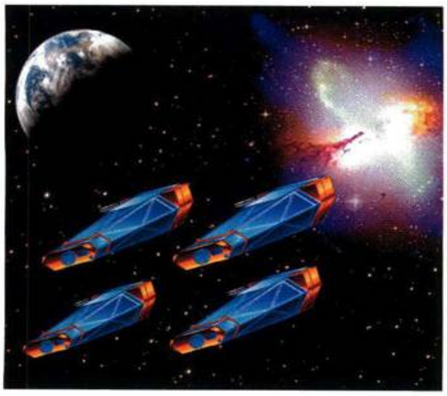
ASTRONOMICAL INSTRUMENTS

Catching photons

Astronomers need to capture every photon possible, but current technologies cannot detect individual photons *and* clock their energies and arrival times. A new single-pixel device that can be linked into an array may change that.

A device built by NASA's Jet Propulsion Laboratory and Caltech has detected a single high-energy X-ray photon; with engineering tweaks it should work with optical light. Later on, arrays of these detectors may help space telescopes spot elusive Earth-like planets.

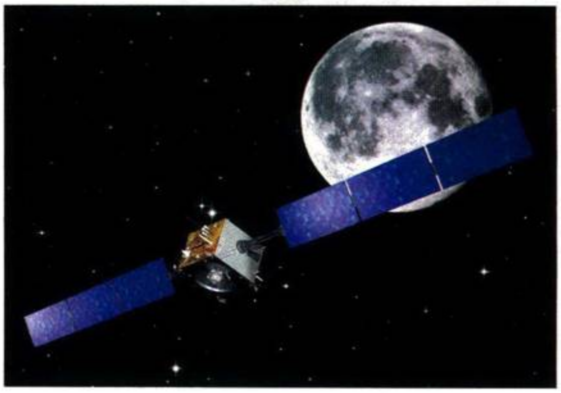


X-RAY SURVEY MISSIONS such as Constellation-X may benefit from a new type of astronomical detector that can spot individual photons. NASA

"When every photon matters," says Caltech's Benjamin Mazin, a team member, "ours or another superconducting technology will be the method of choice." The detector, 0.1 millimeter square, uses an aluminum strip chilled to almost absolute zero. Pairs of electrons called Cooper pairs break apart when a photon strikes the metal. Scientists measure the energy by counting broken Cooper pairs.

Existing single-photon detectors can't be linked easily into an array. The new detectors, however, can work like individual pixels in a CCD camera to produce an astronomical image. These detectors may be used on future space-survey missions such as the Terrestrial Planet Finder and the X-ray interferometer called Constellation-X. — **MAGGIE McKEE**

SMART-1: the slow boat to the Moon



EASY DOES IT: The European Moon probe SMART-1 will study the Moon and Sun while also testing a low-thrust, solar-powered ion engine during an actual space mission. ESA

Slowly spiraling out from Earth, the first European lunar probe is making the longest-ever flight to the Moon — and perhaps blazing a trail for fleets of later space "slow boats."

SMART-1 was launched in September 2003 as a piggyback payload on a commercial Ariane rocket. It popped off its booster into an elongated transfer orbit that ranges between several hundred and 25,000 miles above Earth. Its target is orbiting about 250,000 miles high, and if all goes well, the probe will arrive there at the end of 2004.

The 780-pound Swedish-built SMART probe — Small Missions for Advanced Research and Technology — isn't the first ion thruster to fly in space, but it's the first to use such a low-thrust, long-firing system to escape from near-Earth orbit.

The idea has been around for decades; it was even the strategy for a Walt Disney TV special on a manned Mars expedition back at the dawn of the space age. Neither Disney nor anyone else then knew that slowly spiraling out through the yet undiscovered Van Allen radiation belts would have given astronauts a lethal dose of radiation before they'd even left the Earth–Moon system. SMART-1 was radiation-hardened. Yet in its first few months of flight, it was irradiated strongly from the Van Allen belts and from gigantic solar flares that erupted in early November 2003.

SMART-1's engine uses xenon gas as the propellant. By expelling xenon with electrostatic forces (instead of the thermal expansion of heated, burned propellants that traditional rockets use), SMART-1 can get five to thirty times the thrust of an ordinary rocket. On the other hand, the thrust is so low — about the same force as a sheet of paper exerts on your hand — that SMART-1 could never lift off the ground by itself.

This is about the same thrust used in an earlier project that was never launched: solar sails (or "light sails") — see News, November 2003. Studied by NASA in the early 1980s for use in a Halley's Comet rendezvous mission, the technique also was the basis for an international project (later abandoned) for a "sailing race" to the Moon in the early 1990s. Vehicles from Europe, Japan, Canada, and the United States would have vied to be the first to disappear behind the Moon as seen from Earth.

The future of low-thrust Earth-escape systems, both ion engines and light sails, may lie with projects for lunar bases and even human flights to Mars and nearby asteroids. While the crew would make the trip in a fast (and medically less challenging) vehicle, most of their supplies could be sent ahead on slow boats with low-thrust, efficient propulsion systems.

So there's a lot more riding on SMART-1 than just its impressive suite of science instruments. — **JAMES OBERG**

MARS HAS BEEN DRY a long time, say planetary scientists who have mapped deposits of the green mineral olivine in the Nili Fossae area. Because water decomposes the mineral easily, abundant olivine implies little water.

{ 02:04 }

COSMOLOGY

The big cosmic picture

A team of astronomers has announced a 2-billion-light-year-deep survey map that reveals the most precise architecture of the universe to date. The map confirms previous results, including the existence of dark matter and dark energy.

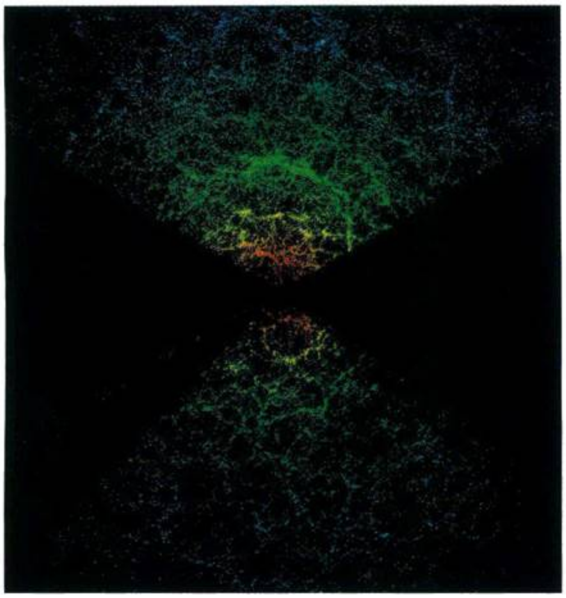
Mining data from the Sloan Digital Sky Survey (SDSS), the astronomers measured the pattern of large-scale clustering of galaxies and their associated dark matter. By plotting the positions of 205,443 galaxies spread over 6 percent of the sky, a group led by Max Tegmark of the University of Pennsylvania obtained the sharpest views yet of patterns of gravitational clustering between galaxies. While the density appears clumpy on a scale of millions of light-years, a more uniform picture emerges on larger scales.

The scientists note that cosmic matter breaks down into 70 percent dark energy, 25 percent dark matter, and only 5 percent ordinary matter made of atoms.

These latest numbers match both theoretical predictions and findings released earlier from the Wilkinson Microwave Anisotropy Probe.

"Different galaxies, different instruments, different people, and different analysis — but the results agree," explains Tegmark.

— ANDREW FAZEKAS



A MAP 2 MILLION LIGHT-YEARS DEEP reveals the universe's structure is clumpy on small scales and smooth on larger ones, confirming and extending earlier results. SDSS

ASTROPHYSICS

Super stars in Lynx

Studying remote galaxies in Lynx, a team of astronomers found a small reddish arc they couldn't identify. When careful study showed it was similar to the Orion Nebula, the scientists realized they were seeing the stretched-out projection of a mega-cluster of starbirth 12 billion light-years away.

Team member Bradford Holden (Univ. of California) says it appears to contain "incredibly massive stars, much larger than almost any in our own galaxy."

— VANESSA THOMAS

THE RED ARC marks the largest-known star-making region. ESA/NASA/R. A. E. FOSBURY

ASTRONOMICAL INSTRUMENTS

Making scopes smart

Telescopes aren't just getting bigger; they're also becoming smarter.

A team led by Tim Naylor (University of Exeter, England) has created an "intelligent agent" computer program dubbed eSTAR. It can identify rapidly changing events, instantly analyze what it's seeing, and coordinate follow-up observations with telescopes worldwide.

A human astronomer will outline an observing program. The eSTAR agent contacts all networked telescopes and picks whichever is best-placed to do the observations.

The agent compares new observations with cataloged data. If it detects something new, it finds the most suitable telescope to follow up.

The smart telescopes, linked via the Grid, or "next generation Internet," will help astronomers study "the most rapid and violent events in the universe," says Alasdair Allan, also at Exeter.

— ROBERT ADLER

SOLAR SYSTEM EXPLORATION

Voyager 1: in interstellar space?

Launched in 1977, the Voyager 1 spacecraft has flown past Jupiter (1980) and Saturn (1981). (Its twin, Voyager 2, also visited Uranus and Neptune.) Now, some ninety times farther from the Sun than Earth is, Voyager 1 seems to have reached interstellar space.

Between August 1, 2002, and February 5, 2003, mission scientists detected readings from onboard instruments that showed Voyager 1 had entered a section of the solar system unlike any previously encountered.

"Voyager 1 is giving us our first taste of interstellar space," says Stamatios Krimigis of the Johns Hopkins University Applied Physics Laboratory. "This is our first direct look at the incredibly dynamic activity at the solar system's edge."

The spacecraft noted a large increase in energetic particles, which, Krimigis says, indicates a plunge in solar-wind speed. This places the spacecraft at or near the point where the solar wind is less significant than interstellar particles.

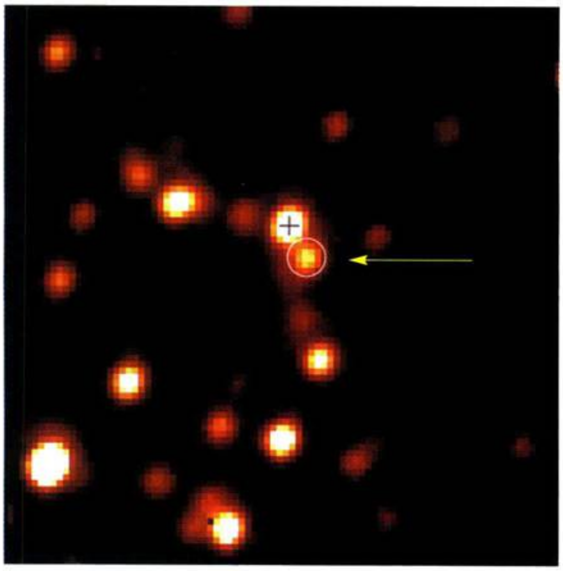
— JEREMY McGOVERN

VOYAGER 1 is detecting signs that it has reached interstellar space. NASA

ICE AT THE LUNAR POLES may be scarcer than believed, say scientists who have bounced radar beams from the Moon's polar regions. The permanently shadowed craters show little or no signature of thick ice deposits.

MILKY WAY GALAXY

The last good-bye



ASTRONOMERS SAW an infrared flare (arrow) as an object vanished into the black hole at the center of the Milky Way. ESO

"What's that star doing there?" exclaimed astronomer Rainer Schödel, disturbing the workday monotony of the Very Large Telescope control room on the morning of May 9, 2003. Schödel, part of an international team studying our galaxy's core, was working with team leader Reinhard Genzel at the Paranal Observatory in Chile that day when they observed an anomaly at the Milky Way's center.

Using an adaptive optics instrument on the 8.2-meter Yepun telescope, Schödel and Genzel had just become the first people to witness the last light emitted by an object as it was devoured by a supermassive black hole.

A few minutes after it appeared, the "star" vanished, confirming that it was a flare signaling its last good-bye in the near-infrared part of the electromagnetic spectrum.

"We had been looking for infrared emission from that black hole for more than a decade," explains team member Andreas Eckhart (Cologne University). "We were certain that the black hole must be accreting matter from time to time. As this matter falls toward the surface of the black hole, it gets hotter and hotter and starts emitting infrared radiation."

The rapidly flickering signals emanating from the black hole's event horizon vary on a scale of minutes, indicating the region has chaotic properties like those of thunderstorms and solar flares. — **KELLY KIZER WHITT**

SPACE MISSIONS

Europe scales back

Budget shortfalls have forced the European Space Agency to cancel Eddington, a mission that would have launched a space telescope designed to find earthlike planets, and to eliminate a lander from BepiColombo, a survey mission to Mercury.

Eddington's goal was to locate terrestrial-type planets outside the solar system. Its instruments also were designed to study the vibrations of stars, letting astronomers examine their structure using a technique called astroseismology. This method already has proven successful in solar research.

The BepiColombo mission, under development with a launch planned for June 2011, still will send two orbiters (one of them built with Japan's space agency) to study the innermost planet. While one orbiter is focusing on the surface, the other will study Mercury's magnetospheric environment.

The canceled lander, called the Mercury Surface Element, would have set down around 85° north or south latitude. — R. B.

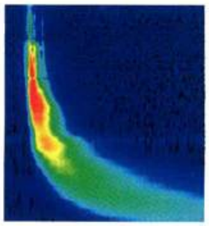
CASSINI MISSION

Listening to solar activity

On October 28, 2003, just 69 minutes after one of the largest-ever solar flares (see story below), the Cassini spacecraft, 8.7 astronomical units from the Sun, heard radio waves emitted by a swarm of electrons ejected from the flare.

"The sound is produced by electrons beginning at a high frequency before dropping to a lower frequency," explains Donald Gurnett (Univ. of Iowa), principal investigator for the instrument that recorded the Sun's natural music.

The recording sounds like something from a sci-fi movie. A synthetic falsetto tone swells suddenly, then gradually drops, like the sound a sleek alien vessel might make if it glided overhead and then flew off into the distance. — **V. T.**



A SOLAR RADIO BURST dropped in pitch as it passed the Cassini spacecraft. UNIV. OF IOWA

SOLAR ASTRONOMY

Biggest solar flare ever recorded

In late October and early November 2003, a series of solar flares erupted that were among the most powerful recorded. One of them, on November 6th, was classed as an X28, making it the strongest since measurements began in the 1970s. The flares saturated X-ray detectors on solar monitoring satellites and caused widespread aurorae at latitudes as low as southern Texas.

AURORAL CURTAINS glowed over Indiana on October 29, 2003, after a gigantic solar flare. ROBERT B. SLOBINS

The flares erupted from active region 486, which was about fifteen times larger than Earth. Flares often are accompanied by coronal mass ejections, huge outpourings of charged particles. When these reach Earth, they overload the magnetosphere and spill into the upper atmosphere, causing aurorae. — **R. B. AND MICHAEL BAKICH**

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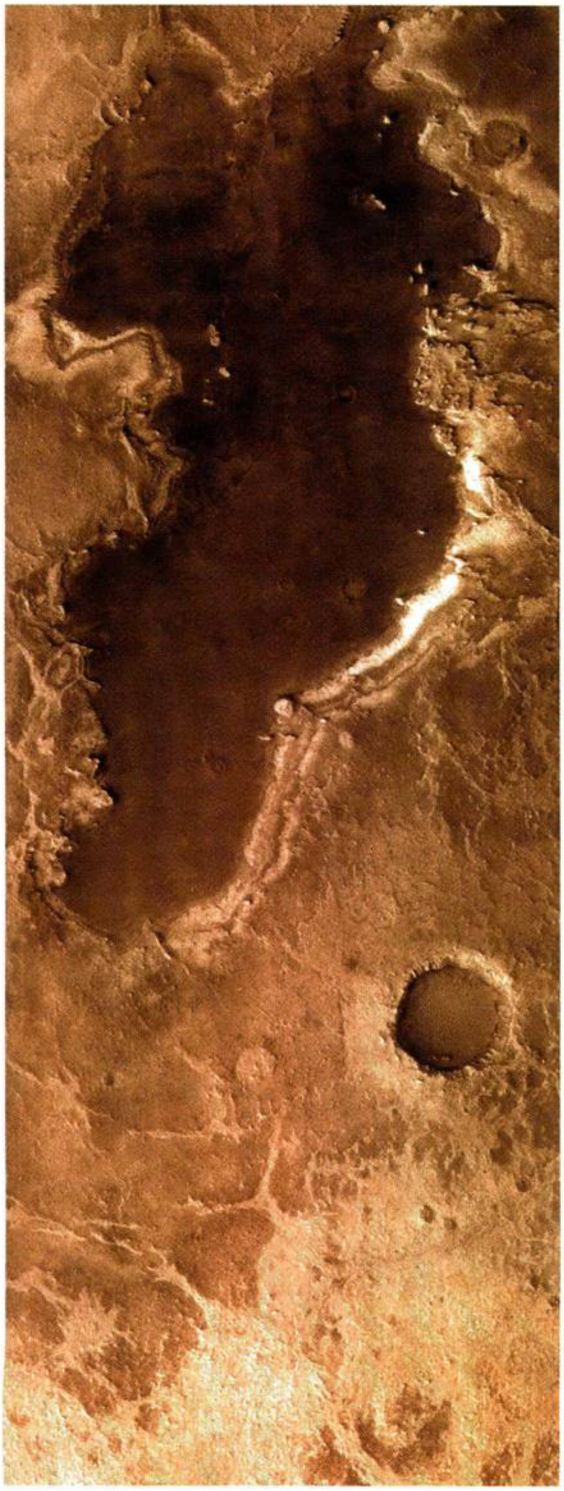
A NEW STAR is forming a massive planet, according to astronomers. They found the disk of dust surrounding star HR 100546 has a gap. That is probably where a Jupiter-like planet is clearing out dust as it forms.

Meridiani Planum basin



AN IRREGULAR BASIN in Meridiani Planum (top) on Mars shows a dark deposit, perhaps hematite, which also fills a nearby crater's floor. NASA/JPL/ASU/IMAGE 20031017A

ASTROBIOLOGY

"Mars soil" on Earth

If the Viking landers that looked unsuccessfully for life on Mars in the 1970s had landed in Chile's hyper-arid Atacama Desert, their instruments likely would not have detected life on Earth either, reports a team of planetary scientists.

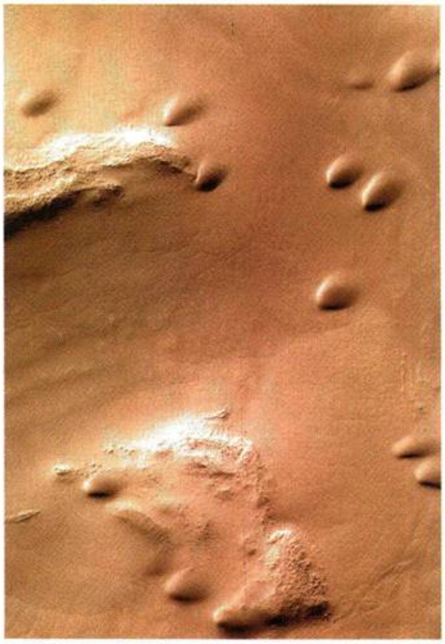
Viking found martian soil to be devoid of organic compounds. But it also found the soil was highly reactive — when wet, it emitted lots of molecular oxygen, which would be expected if organic matter was being consumed.

This contradiction has puzzled scientists for nearly thirty years. But recent field tests in the Atacama produced results similar to those the Viking landers saw.

"If Viking landed there instead of Mars," says principal investigator Chris McKay (NASA Ames), "we would have been shut out."

"The Atacama is the only place on Earth where I've taken soil samples back to the lab and nothing grew," says Fred Rainey (Louisiana State Univ.). This makes the Atacama highly valuable for creating instruments to look for life on Mars. — R. B.

MARS PHOTOJOURNAL

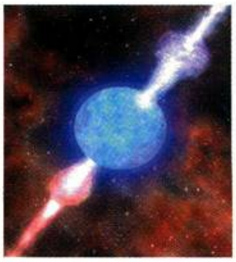


SAND DUNES IN HELLAS PLANITIA have settled into smoothly rounded mounds, as seen in this photo taken by the MOC camera aboard the Mars Global Surveyor spacecraft. The local season is mid-southern autumn. Sunlight illuminates the scene from the upper left, and the image covers an area about 1.9 miles (3 kilometers) wide. NASA/JPL/MALIN SPACE SCIENCE SYSTEMS/IMAGE M20-01676

GAMMA-RAY BURSTS

GRBs, X-ray flashers the same?

Gamma-ray bursts (GRBs) are powerful explosions, but they differ in brightness, hinting that some have more power than others. Not so, says new research on a GRB that erupted March 29, 2003.



GAMMA-RAY BURSTS and X-ray flashers appear to originate as massive stars collapse. DANA BERRY

"For some reason, these explosions put greatly varying percentages of energy into gamma-rays," says Dale Frail (National Radio Astronomy Observatory). That means strong and weak GRBs, plus X-ray flashers (which emit almost no gamma rays), are varieties of the same mechanism.

That mechanism is a giant star collapsing into a black hole. Its powerful gravity pulls the star's remains into a disk that swirls around the black hole for a few seconds.

As this occurs, the disk shoots material from its poles. Moving at nearly the speed of light, the jetted material emits gamma rays, while slower-moving material in the jet emits radio waves and visible light — **R. B.**

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Meet our Astronomical Bon Vivant!

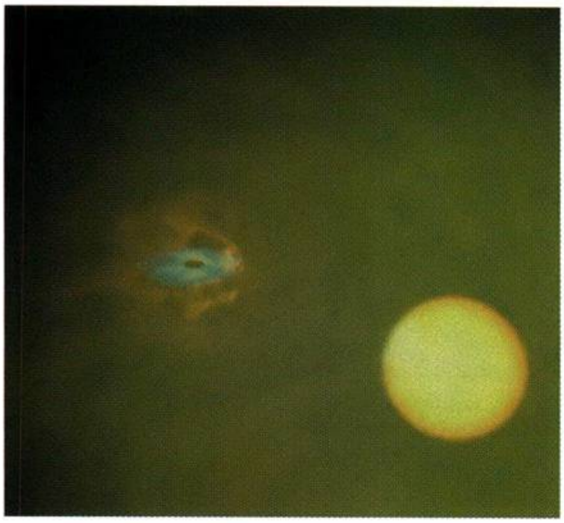
An amateur astronomer since the age of nine, doing everything from building telescopes from scratch to CCD astrophotography, Tim Cann's pretty much "been there, done that." As a 25-year member of Stony Ridge Observatory (SRO), used by NASA to help map the moon for the lunar landing, Tim computerized its 30" Newtonian/Cassegrain instrument. Today he provides equipment support for the Faint Object Follow-Up team at SRO, that observes asteroids fainter than 19th magnitude and reports astrometric information to the Minor Planet Center. In addition to his computer consulting business, Tim writes and programs **lrgb.com**, the CCD astrophotography website.

On the lighter side, Tim loves to cook. Unlike his rigorous astronomy and computer methodology, he uses a dump-and-taste approach. Good wine and good espresso with excellent food in the middle is his only requirement. Call him and he'll be happy to answer your questions!

SAND RIPPLES PILE UP HIGHER on Mars than on Earth, according to results from stereo images using the Mars Global Surveyor's MOC camera. Imagine terrestrial sand ripples with twice the height but the same length.

HIGH-ENERGY ASTROPHYSICS

Black holes that hide



A HAZE OF GAS from a supermassive star [right] is pulled into a compact black hole [left]. But the gas cloaks the system from view, letting through only high-energy radiation. ESA ARTWORK

A previously unknown class of astronomical objects has been lurking undetected in our galaxy. Discovered by the European Space Agency's gamma-ray space telescope, Integral, the objects appear to be binary systems made up of a supermassive star and its compact companion, probably a black hole or neutron star.

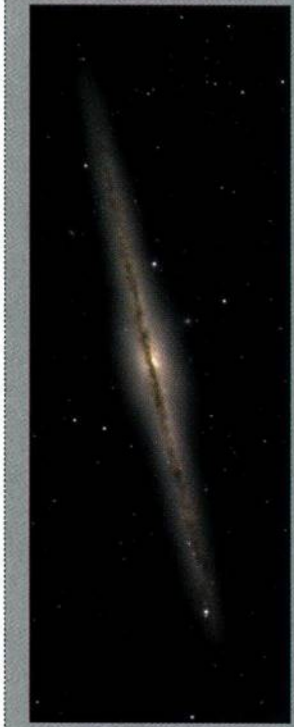
But like a celestial Harry Potter, the star has wrapped itself and its companion in the equivalent of an invisibility cloak — a blanket of dense, cold gas that shields the two of them from all but the most probing of views.

The star expels this gas in all directions as a powerful stellar wind. Nearby, the black hole collects the gas with its tremendous gravity. As the gas funnels inward, it accelerates, throwing off radiation across the spectrum. But only the most energetic of wavelengths penetrate the cloud, according to Roland Walter, principal researcher. Neither visible nor infrared light escapes to be seen by other telescopes.

Integral first detected the object (IGRJ6318-4848) on January 29, 2003, when it found gamma rays pouring from the spot. Theorizing that dense gas otherwise clouded the view, the researchers focused ESA's XMM-Newton space telescope on the same patch of sky. This telescope, which is optimized for detecting X rays, can peek through barriers that otherwise cloak objects. The two telescopes already have located two other hidden systems, and astronomers are planning to search for more. — **JESSA FORTE NETTING**

GALAXIES

Stars and dust



EDGE-ON GALAXY NGC 891 was an early target for a new infrared CCD camera at the University of Hawaii. U. HAWAII

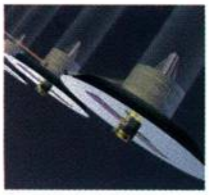
ASTRONOMICAL INSTRUMENTS

Seeing sharply for less

Astronomers may not need giant space-based interferometers (like the proposed Terrestrial Planet Finder, seen below) for studying extrasolar planets directly.

Researchers led by William Danchi (Goddard Space Flight Center) found that by rotating a small space-based interferometer around its line of sight, and by contrasting signals at two infrared "colors," a pair of half-meter telescopes on a 12-meter boom could detect many extrasolar planets and glean spectroscopic information about their atmospheres.

"People talk about spectrometry [of exoplanets] with structures the size of a football field," says Marc Kuchner (Princeton Univ.). "We think we could do it with something that would fit in your driveway." — **ROBERT ADLER**

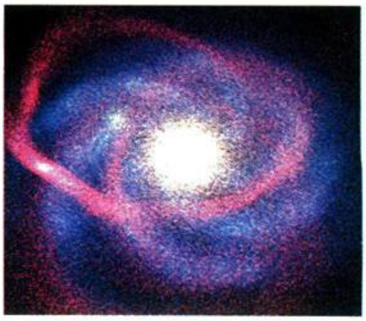


A CLEVER technique might replace giant interferometers. NASA

MILKY WAY GALAXY

New "nearest galaxy" found

A new galaxy has been discovered that's the closest to our own Milky Way Galaxy. A dwarf irregular in type, the new galaxy lies in the constellation Canis Major, just 42,000 light-years away.



STREAMS OF STARS from the Canis Major dwarf galaxy are being absorbed into the Milky Way. STRASBOURG OBS. ARTWORK

But look quickly. Like most dwarf galaxies near a large spiral such as the Milky Way, the Canis Major dwarf is being torn apart by our galaxy's gravity. On a cosmically short timescale, its stars and gas will be absorbed totally into the Milky Way's disk.

The Canis Major dwarf turned up in the Two-Micron All-Sky Survey (2MASS). It had remained hidden because it lies in the plane of the Milky Way, where dust and gas obscure the view. The survey spotted it at infrared wavelengths, which can penetrate dust. — **R. B.**

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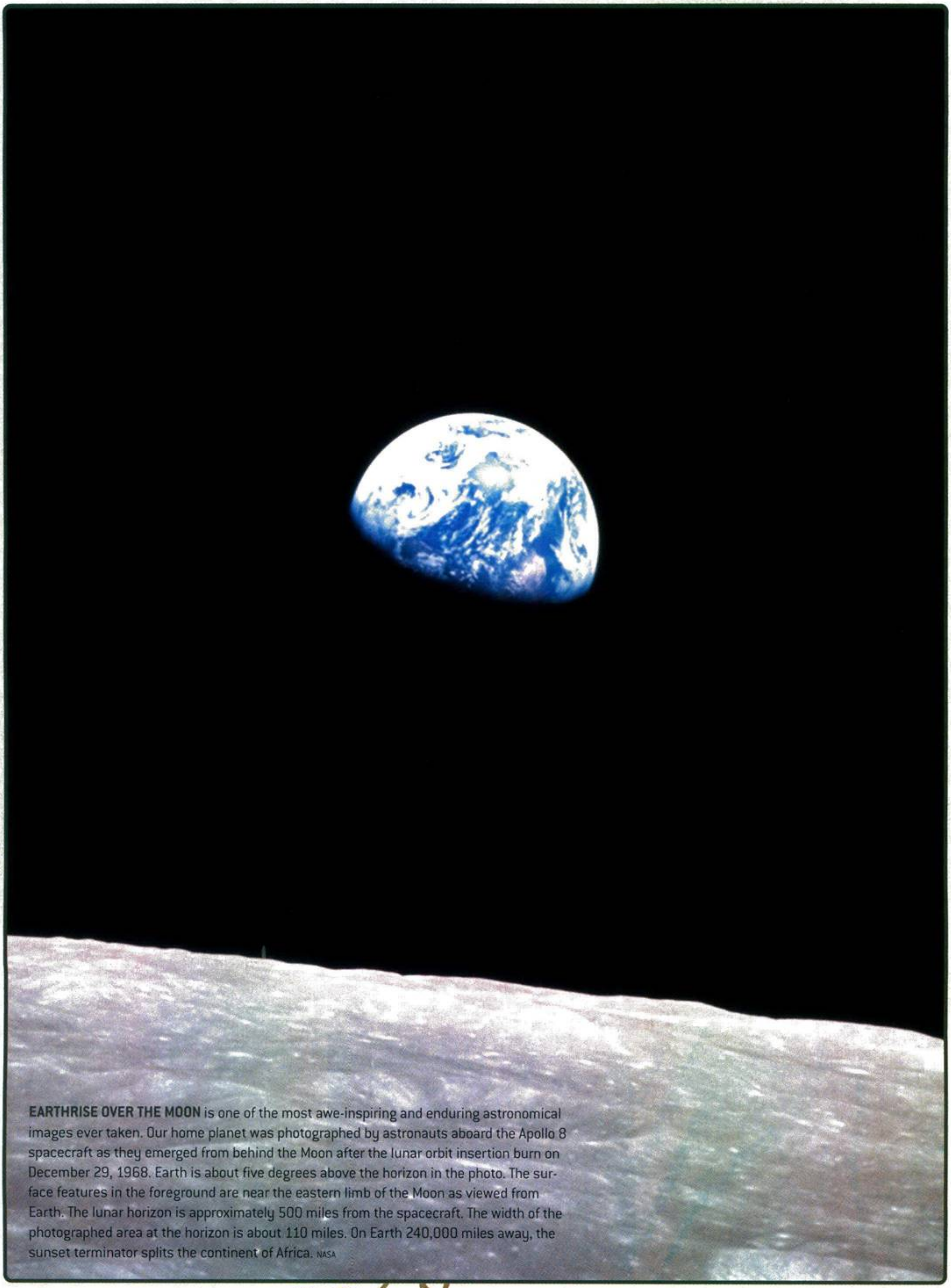
The 25 GREATEST ASTROPHOTOS IN HISTORY

/// BY MICHAEL E. BAKICH ///

MILLIONS OF IMAGES OF CELESTIAL OBJECTS have been created since the first one was taken more than 160 years ago. In the September 2003 issue, we highlighted thirty of the most beautiful and significant, but because we were celebrating *Astronomy*'s 30th birthday, we chose only those images made after August 1973. That got us thinking: What if we didn't restrict the time frame to the last 30 years? The magnificent — and important — images that follow over the next seven pages are the result.

Several images are beautiful; others are not. The early ones are black and white. All are towering, however, in the history of astronomy. To help you put the images in their proper context, I've crafted a brief history of astronomical photography.



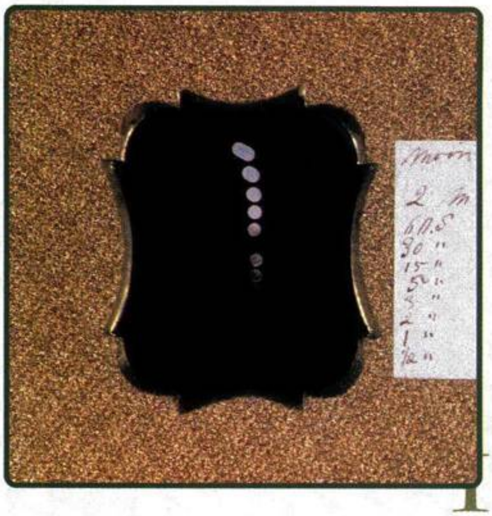
EARTHRISE OVER THE MOON is one of the most awe-inspiring and enduring astronomical images ever taken. Our home planet was photographed by astronauts aboard the Apollo 8 spacecraft as they emerged from behind the Moon after the lunar orbit insertion burn on December 29, 1968. Earth is about five degrees above the horizon in the photo. The surface features in the foreground are near the eastern limb of the Moon as viewed from Earth. The lunar horizon is approximately 500 miles from the spacecraft. The width of the photographed area at the horizon is about 110 miles. On Earth 240,000 miles away, the sunset terminator splits the continent of Africa. NASA

1968

Hazy beginnings

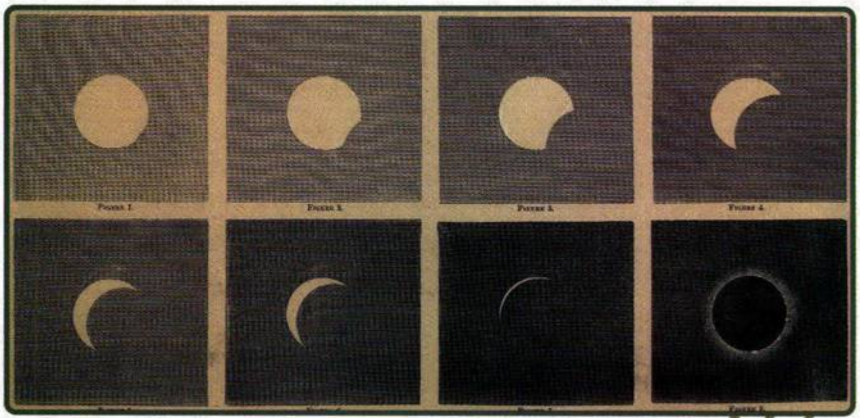
The development of the photographic process was long and involved, stretching back to at least 1826, when French scientist Joseph Nicéphore Niepce made the first surviving photograph on a pewter plate. Probably the best-known individual who independently discovered the photographic process is the French artist and set designer Louis Daguerre, who later became a friend of Niepce's. He accidentally discovered how to develop a photographic image in 1835. Daguerre used a thin layer of silver deposited on a copper plate. The silver was made light-sensitive by placing the plate in a container with iodine vapor. The plate was then exposed to light (a lens focusing an image on it) and developed by heating mercury to 150° Fahrenheit, allowing particles of its vapor to condense on the exposed silver. The more light struck the silver, the more mercury was deposited there. This process produced an image, but two years passed before Daguerre discovered how to "fix" the image (keep it from fading) once it was developed. Daguerre's process, which produced a type of image called a daguerreotype, was deemed so important by the French government that it purchased the rights from Daguerre (allocating him an annual pension of 6,000 francs) and distributed the process free to the world in 1839. Shortly after this announcement, astronomer John Herschel coined the term *photography* in a paper presented to The Royal Society, the United Kingdom's academy of science. (Herschel also coined the terms *negative*, *positive*, and *snapshot*.)

Early daguerreotypes had several shortcomings. Each was a "once only" process (meaning copies could not be made), the images created were *fragile* (not many early daguerreotypes survive today), and the exposure times were extremely long. It seems amazing then that the first good astrophoto — a picture of the Moon — was taken in 1840 by John William Draper in New York City. (Actually, Daguerre had taken a photograph of the Moon in 1839, but no



◀ **THE MOON** was the first celestial object to be photographed. Its first portrait, a 20-minute exposure through a 5-inch Newtonian reflecting telescope, was taken by John W. Draper in 1840. Unfortunately, that image has been lost. More successful attempts (mainly due to improvements in the quality of daguerreotype plates) were made at Harvard College Observatory in the late 1840s and 1850s. The earliest surviving picture in Harvard's collection (actually a series of images with different exposure times) is shown here. It was taken by John A. Whipple, William C. Bond, and George P. Bond. HARVARD COLLEGE OBSERVATORY

1849



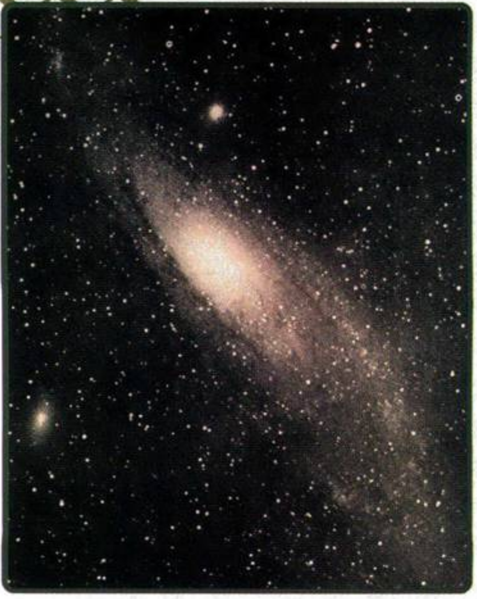
1869

▲ **TOTAL SOLAR ECLIPSES** were important events in the 19th century because they were the only way to study the Sun's outer atmosphere, the solar corona. Observers often traveled to remote locations halfway around the world to view totality. A team of Harvard University astronomers observed the solar eclipse of August 7, 1869, from Shelbyville, Kentucky. Facsimiles of the photographs were reproduced in the August 28 *Harper's Weekly*. The photographer was none other than John A. Whipple, one of the three men who first successfully photographed a star — Vega — in 1850. *HARPER'S WEEKLY*

1888

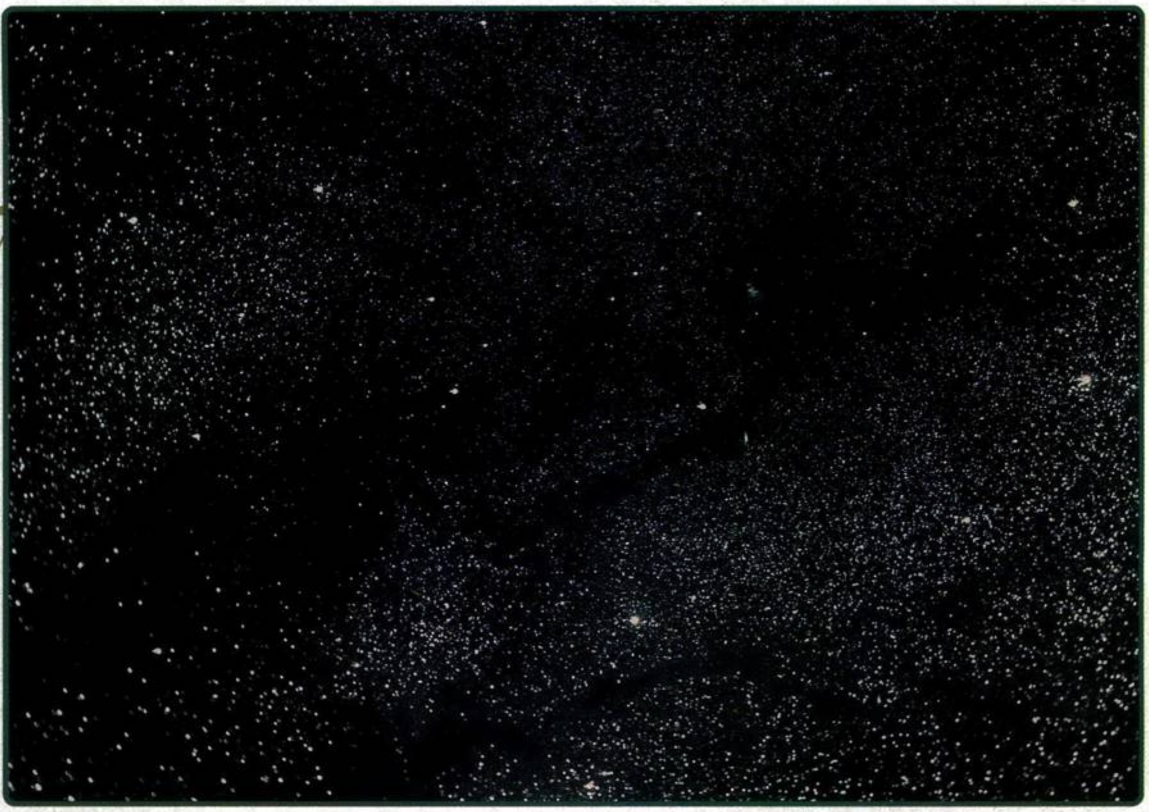
▶ **THE ANDROMEDA GALAXY** (M31) is one of the most photographed celestial objects of all. Imagine, however, a time when no good image of M31 existed — when the characteristics of the object itself were unknown. All that changed on December 29, 1888, when Isaac Roberts, a Welsh amateur astronomer, took this groundbreaking photograph showing the Andromeda galaxy's spiral structure and stars in its outer regions. This image and studies by Edwin Hubble (see the image dated 1923 on page 37) proved the existence of galaxies other than our Milky Way. Roberts used a 20-inch f/5 reflector made specifically for astrophotography by Howard Grubb & Sons.

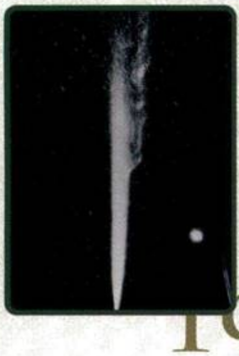
A SELECTION OF PHOTOGRAPHS OF STARS, STAR CLUSTERS, AND NEBULAE BY ISAAC ROBERTS (THE UNIVERSAL PRESS, 1893)



1907

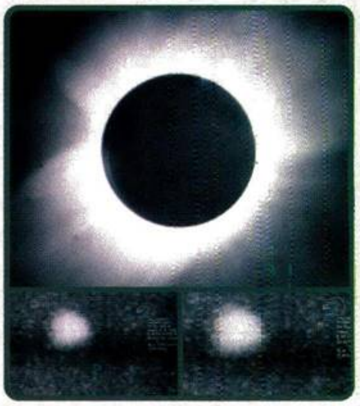
▶ **OUR GALAXY** was captured beautifully by American astronomer Edward Emerson Barnard. Taken between 1904 and 1916, the fifty-one plates show 349 dark nebulae that Barnard cataloged. Of Plate 5 — the nebulous region in Taurus — Barnard said, "Very few regions of the sky are so remarkable as this one. Indeed the photograph is one of the most important of the collection, and bears the strongest proof of the existence of obscuring matter in space." *THE PHOTOGRAPHIC ATLAS OF SELECTED REGIONS OF THE MILKY WAY* (CARNEGIE INSTITUTION OF WASHINGTON, 1927)





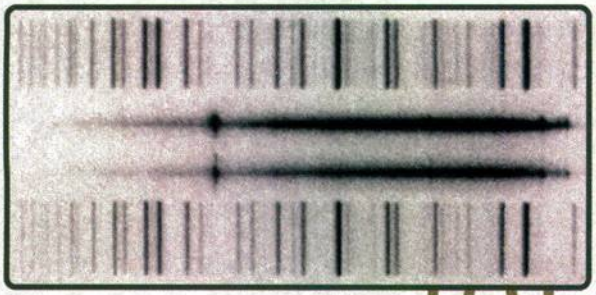
◀ **HALLEY'S COMET** is one of the best known of all astronomical objects. This photograph — probably the most famous of the comet — was taken May 13, 1910, by a wide-angle camera at Lowell Observatory in Flagstaff, Arizona. The streak across the comet near its coma is a meteor trail; streaks at the bottom right are Flagstaff's city lights. Venus shines above the lights. LOWELL OBSERVATORY

1910



1919

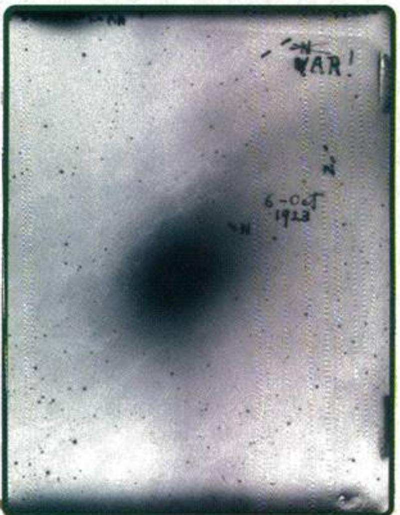
◀ **ALBERT EINSTEIN'S NAME** became a household word after this picture was taken. In 1912, Einstein stated that the warping of space by matter can cause starlight to bend as it passes a massive object such as the Sun. British astronomer Sir Arthur Eddington traveled to a total solar eclipse on May 29, 1919, to test Einstein's theory. The positions of the stars (inset) varied by the amount Einstein had predicted. The only usable photograph from the eclipse was this one — but it proved to be enough. ROYAL GREENWICH OBSERVATORY



1914

▲ **THE EXPANSION OF THE UNIVERSE** got its first strong evidence from Vesto Melvin Slipher, an astronomer at Lowell Observatory. In 1914, he reported the Andromeda Galaxy (M31) was moving toward us at 200 miles per second. Slipher noted the average velocity of a spiral galaxy was roughly twenty-five times larger than the average stellar velocity, and all but a few nearby galaxies were moving away from us. This spectrogram shows the light from NGC 3395 and NGC 3396, a pair of interacting galaxies in Leo Minor, shifted toward the red end of the spectrum, indicating the galaxies are moving away from us. LOWELL OBSERVATORY

▶ **EDWIN HUBBLE'S** careful scrutiny of photographic plates of the Andromeda Galaxy (M31) led to an insight. Instead of being a nova, one star in M31 brightened and dimmed, revealing itself to be a Cepheid variable — a star whose period is related to its brightness. Calculating its distance, Hubble found the Andromeda "nebula," as it was known at the time, could not possibly lie within our own galaxy. After this epiphany, Hubble took his pen to the plate, crossed out the "N" (representing nova) and scribbled "VAR!" (variable). CARNEGIE INSTITUTION OF WASHINGTON



1923

details could be seen.) Draper's photograph, which required a 20-minute exposure through a 5-inch Newtonian reflector, showed the prominent light and dark markings of the Moon in an image 1 inch in diameter.

Ten years after Draper produced his historic daguerreotype of the Moon, Harvard College Observatory Director William Cranch Bond; his son, George Phillips Bond; and Boston photographer John Adams Whipple photographed a star. On July 16, 1850, they exposed a daguerreotype plate for 100 seconds to produce an image of Vega.

The following year, a new photographic process called the wet collodion method was invented. This was a rather intricate, even dangerous process, due to the chemicals involved (such as sulfuric acid). But it had one big advantage over the daguerreotype process — it dramatically reduced exposure times. At Harvard, the Bonds saw the advantage of shorter exposure times and switched from daguerreotypes to wet collodion plates. Using this method, they produced several hundred photographic images of the Moon, planets, and stars.

Photography dries up

In 1878, Charles Bennett changed the world of photography when he invented the dry-plate process. This was a glass plate coated with a light-sensitive emulsion that was dry to the touch. Plates made this way had many advantages. Any number of plates could be prepared in advance and stockpiled; their quality and standardization improved as the number of plate manufacturers grew; and the process reduced exposure times because it was much more sensitive to light than previous techniques. With constant improvements, the dry-plate process remained the standard for the next century.

In 1907, Auguste and Louis Lumière invented the first practical color photography process. Because color developing techniques are more

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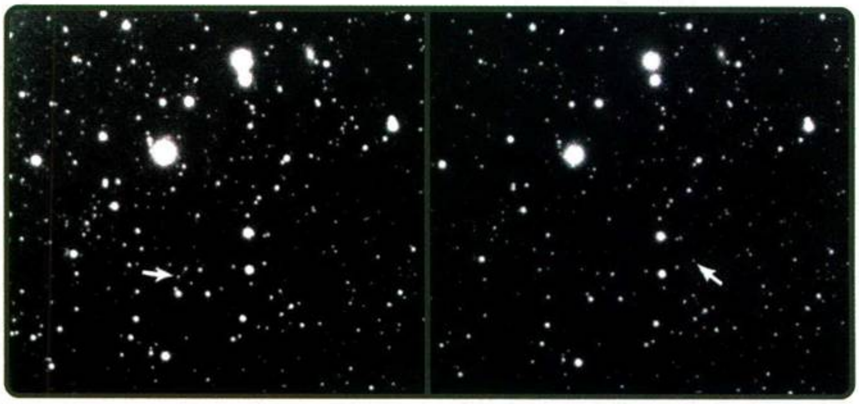
Michael E. Bakich *is an associate editor of* Astronomy.

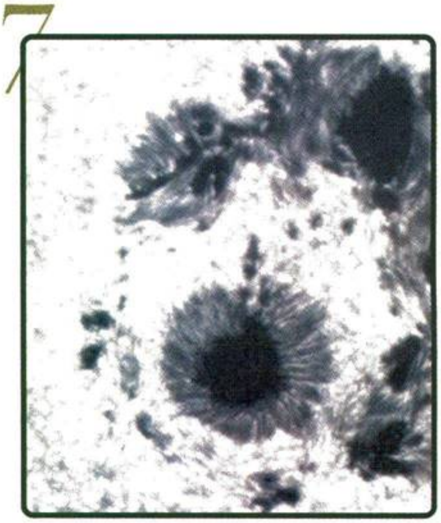


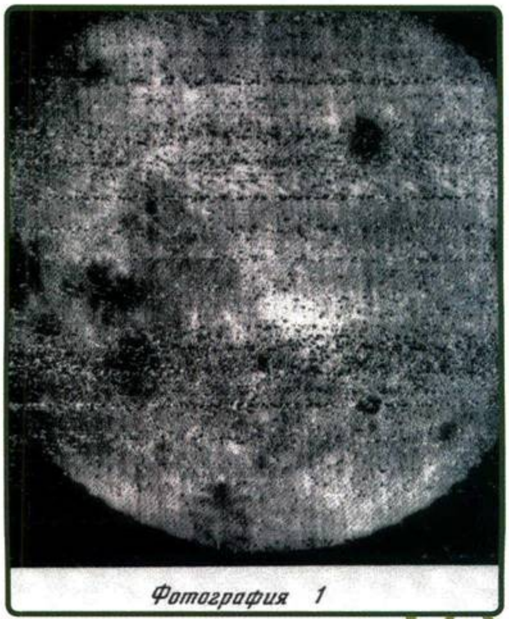
▲ **PLUTO** was the only planet discovered in the 20th century. Clyde W. Tombaugh found it as part of a massive search at Lowell Observatory in Flagstaff, Arizona. On February 18, 1930, Tombaugh compared a plate taken January 23 of that year to one taken six days later. "I knew immediately I'd found the planet we were searching for," Tombaugh later said. "The small amount of shift over the time between plates gave it away." In the search for Pluto, Tombaugh estimated he had compared the positions of more than 90 million star images. Interestingly, the announcement of the discovery of Pluto was not made public until March 13, 1930 — the 75th anniversary of the birthday of the founder of Lowell Observatory, Percival Lowell. LOWELL OBSERVATORY

1930

1957

► **THE STRATOSCOPE PROJECT** was created in the 1950s to take high-resolution photographs of the Sun. A 12-inch telescope mounted on a precise pointing platform was released from Brighton, Minnesota, and lifted by balloon above the stratosphere to a height of more than 80,000 feet. Attached to the telescope was a 35mm movie camera that automatically exposed one frame of film each second. After many refinements of equipment and techniques, the project succeeded in producing the best pictures of the Sun's surface to date, confirming the existence of convection in the solar atmosphere. Princeton University astronomer Martin Schwartzschild conceived and directed Stratoscope, which is now viewed as a predecessor of the Hubble Space Telescope. NASA

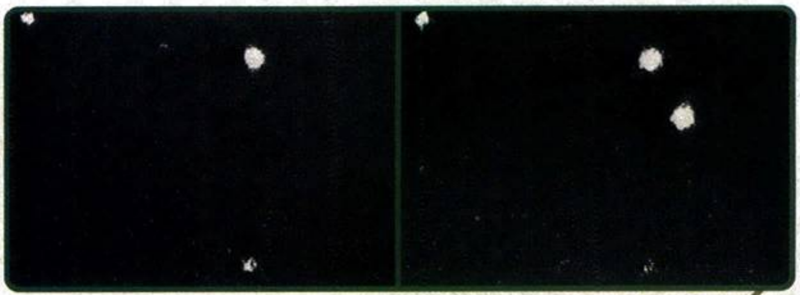




◄ **THE FAR SIDE OF THE MOON** was imaged for the first time by Luna 3, a spacecraft launched by the former Soviet Union. This image was taken at 03h30m UT on October 7, 1959. Luna 3 had passed the Moon by about 39,000 miles and was looking back at its sunlit far side. Twenty-nine photographs were taken, covering 70 percent of the far side. The photographs were very noisy and of low resolution, but many features could be recognized. This image, taken by Luna 3's wide-angle lens, showed the far side of the Moon to be very different from the near side, most noticeably in its dearth of maria (dark areas). The right three-quarters of the disk are the far side (north is up). NASA IMAGE ARCHIVES

1959

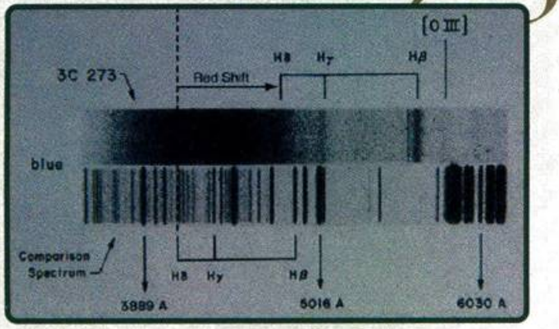
► **A PULSAR** is a rapidly rotating neutron star that emits bright pulses over time. This pulsar, located in the Crab Nebula (M1), helped scientists confirm that pulsars are formed by supernova explosions. In 1969, James M. Miller and Ernest J. Wampler of Lick Observatory near San Jose, California, made a video movie of the Crab pulsar. By strobing (interfering with) the video image, Miller and Wampler could "turn on" or "turn off" the pulsar. Two frames of the video appear at right. The left frame shows the pulsar near minimum brightness, and the right frame shows it near maximum. NOAO



1969

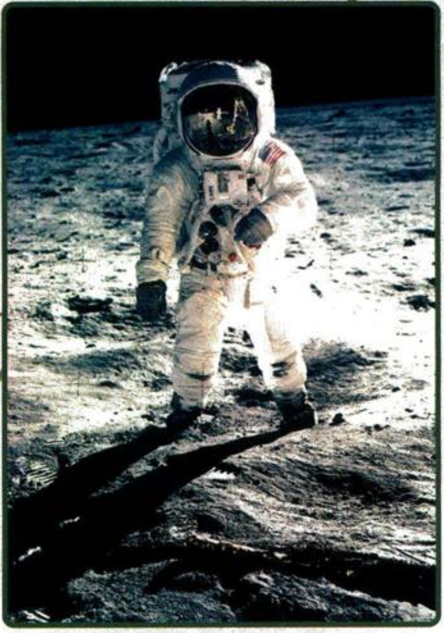
▼ **QUASAR 3C 273** is a strong radio source in the constellation Virgo. Quasars (quasi-stellar objects) radiate a hundred times more energy than most galaxies and are thought to be powered by supermassive black holes. The first quasar spectra seemed to show dark lines characteristic of specific elements, but the lines did not lie in their usual places. After staring at the spectrum of 3C 273 long enough, Dutch astronomer Maarten Schmidt finally recognized a set of lines that were shifted toward the red end of the spectrum by a factor of 0.16. This meant the quasar was traveling away from Earth at 16 percent the speed of light (nearly 30,000 miles per second). MOUNT WILSON AND PALOMAR OBSERVATORIES

1963

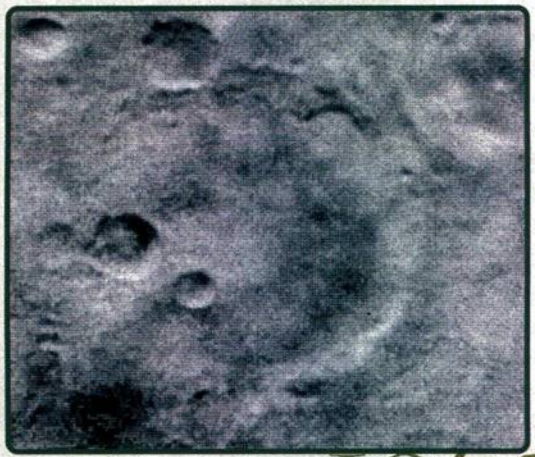


► **ASTRONAUT BUZZ ALDRIN,** the second human to set foot on the Moon and the lunar module pilot for Apollo 11, stands near the leg of the lunar module Eagle during an extravehicular activity. Astronaut Neil A. Armstrong, mission commander and first on the Moon, took this photograph with a 70mm lunar surface camera. While astronauts Armstrong and Aldrin descended in Eagle to explore the Sea of Tranquility region of the Moon, astronaut Michael Collins, command module pilot, remained with the command and service module Columbia in lunar orbit. Tranquility Base, as it was called, was one of five possible landing sites for Apollo 11. Each was mapped in detail with telescopes and by spacecraft prior to the selection of Tranquility. NASA

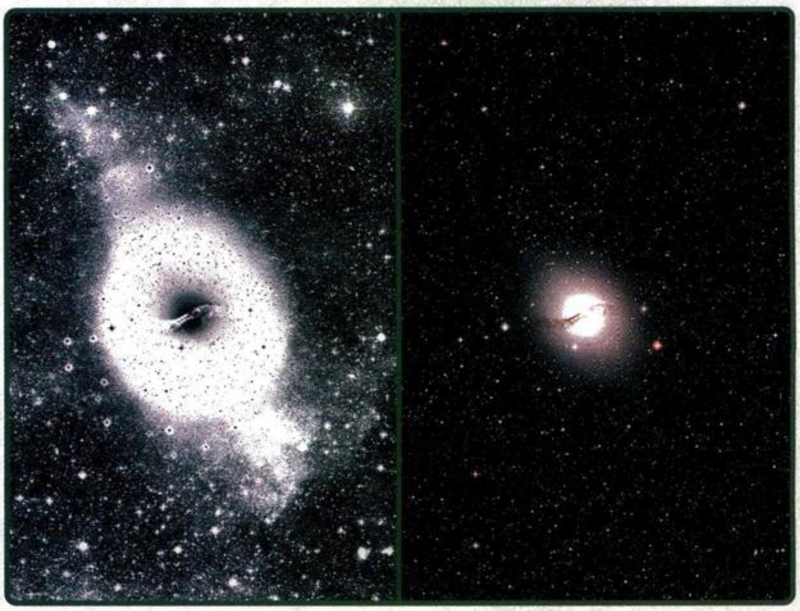
1969



▼ **MARINER 4** was the first spacecraft to send back detailed pictures of Mars. Launched on November 28, 1964, the craft arrived at the Red Planet on July 14, 1965. Flying as close as 6,000 miles to Mars, Mariner 4 revealed a cratered, rust-colored surface with etching possibly caused by liquid water. A television camera took twenty-two pictures covering about 1 percent of the planet. This image (Frame 11E) shows the 90-mile-wide martian crater named after Mariner. The image was taken from 7,500 miles away and covers 150 by 150 miles (north is up). NASA



1965



▲ **A NEW TECHNIQUE** that used diffuse light to reveal faint background detail in photographic prints was pioneered at the Anglo-Australian Observatory in the late 1970s. Compare the large, enhanced contrast image on the left to the image on the right, which shows much less detail. Amazingly, not only do both pictures show radio galaxy Centaurus A, but they also were made from the same plate and are reproduced here at the same scale. Such techniques were refined throughout the 1980s until the advantages of CCD cameras surpassed them. PHOTOGRAPHS FROM UK SCHMIDT TELESCOPE; PLATES BY DAVID MALIN

1979

sensitive to factors such as temperature, astronomers didn't produce color photographic plates until the 1960s, and then only occasionally. Today, you almost never see a black-and-white image — false colors usually are added to highlight specific details or to give form to the invisible: radio, microwave, infrared, ultraviolet, X-ray, and gamma-ray light.

Into the Silicon Age

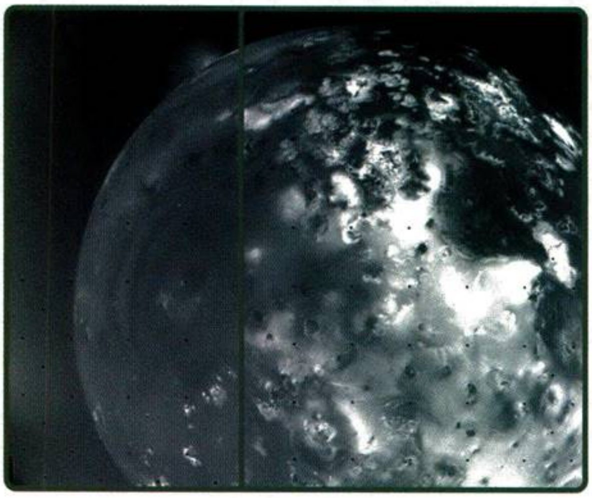
In the 21st century, photographic plates and emulsions are a thing of the past. Imaging is now computerized, and the medium is an electronic chip — a charge-coupled device (CCD). In 1975, the planet Uranus was the first celestial object to be imaged digitally with a CCD camera by astronomers from the University of Arizona and NASA's Jet Propulsion Laboratory. The near-infrared image was obtained using a CCD camera custom-built by Texas Instruments connected to the 61-inch telescope on Mount Bigelow, near Tucson, Arizona. From that point on, astronomers never looked back.

Today's color CCD images are actually an amalgam of three separate exposures using the same CCD camera. Each of the exposures, however, is taken through a different color filter. The usual combination is RGB — red, green, and blue — but CMY (cyan, magenta, yellow) and other colors are used sometimes. Image-processing software aligns and combines the three versions of the image.

CCD imaging represents a quantum leap in astrophotography because of its exquisite sensitivity to light. Observers may balk at the higher cost of a CCD setup, but the instant gratification of seeing images in real time — as opposed to waiting for photos to be developed — may ease any financial pain.

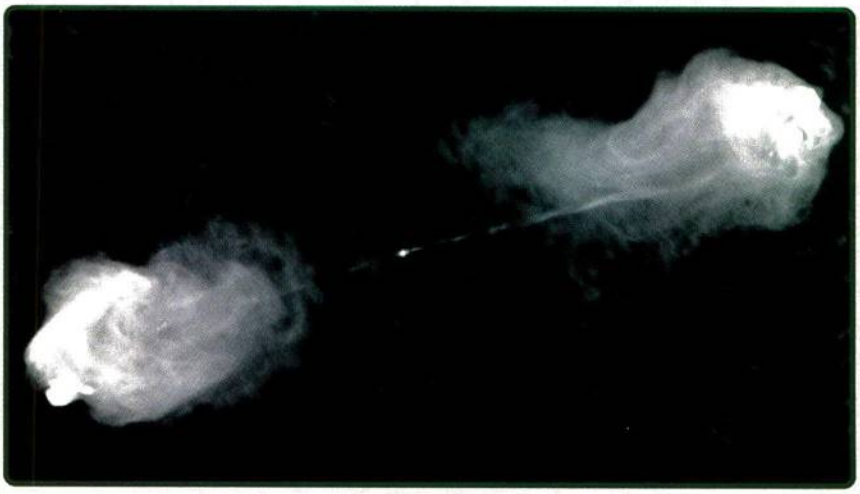
Did we miss one?

Of course, your list of significant astrophotos may vary from ours. If we've missed one of your favorites, please tell us. Go to Astronomy.com and post your picks in the forum. For now, though, just sit back and enjoy this gallery of historic sky shots. **A**



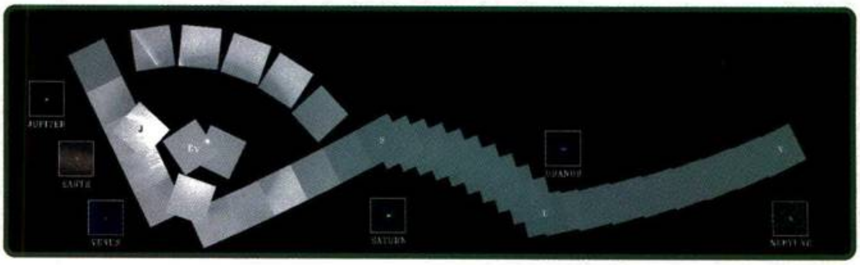
◀ **VOLCANOES** on Jupiter's innermost large moon, Io, were imaged for the first time in the summer of 1979 by the Voyager spacecraft. In one image, Linda Morabito, a member of the Voyager navigation team, discovered a spherical artifact near Io's limb. Further study revealed an illuminated plume emanating from what appeared to be a volcano. The two Voyager spacecraft spotted a total of eight active volcanoes on Io. NASA

1979



▲ **CYGNUS A** was one of several galaxies imaged with radio telescopes starting in the 1960s and is the most powerful by far, emitting a great deal of energy in radio wavelengths. At a distance of about 700 million light-years, it remains mysterious. Cygnus A is characterized by faint, narrow jets, distinct lobes, and clear hot spots at the outer edges of the lobes, often where jets intersect them. This radio image of Cygnus A shows two clumps of luminous material, which led astronomers Walter Baade and Rudolph Minkowski to speculate that the radio emission was somehow linked to a collision between two galaxies. NRAO (RICK PERLEY, JOHN DREHER, AND JOHN J. COWAN)

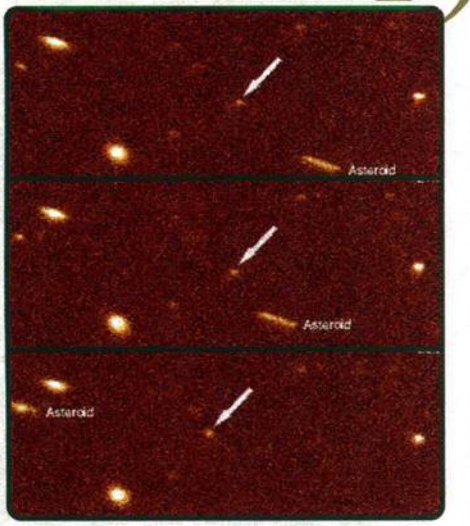
1979



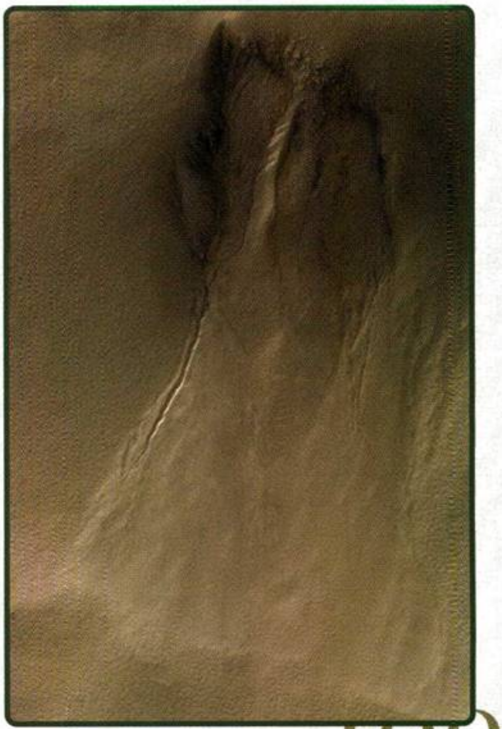
▲ **OUR SOLAR SYSTEM** was photographed by the cameras of Voyager 1 on February 14, 1990. Voyager, from a distance of nearly 4 billion miles, looked back toward the Sun and created the first ever portrait of our solar system, a mosaic consisting of sixty frames. The Sun is seen as the bright object in the center of the circle of frames. The image of the Sun was taken with the camera's darkest filter and the shortest possible exposure (1/5,000 second) to avoid saturating the camera with sunlight. Even at Voyager's distance, the Sun is still almost 8 million times brighter than the brightest star in Earth's sky, Sirius. Narrow-angle images of Earth, Venus, Jupiter, Saturn, Uranus, and Neptune were acquired as the spacecraft built the mosaic. (The insets show the planets magnified many times.) NASA/JPL

1990

1992



◄ **THE FIRST KUIPER BELT OBJECT** to be imaged carries the designation 1992 QB1. This picture of it was taken September 14, 1992, using the University of Hawaii's 87-inch telescope atop Mauna Kea. The Kuiper Belt is a ring of small objects surrounding our solar system at distances between thirty and fifty times the Earth-Sun distance. Approximately 100,000 objects with diameters larger than 50 miles exist in this region. Kuiper Belt objects are thought to be primitive remnants from the early solar system. The inner, denser parts of what became our solar system condensed into the major planets and their moons, but the outer parts were less dense, so no large bodies were able to form. DAVID JEWITT AND JANE LUU

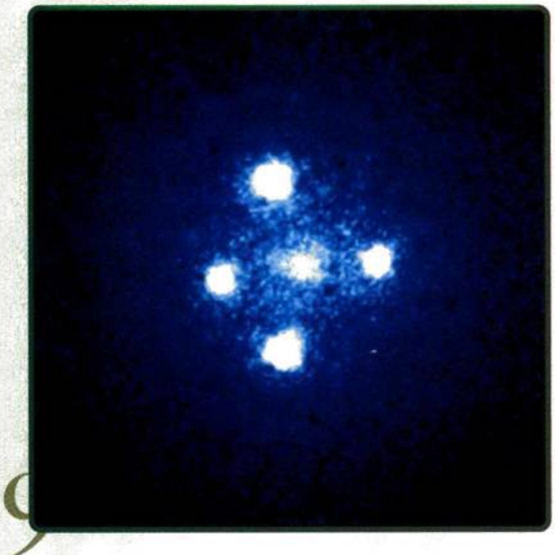


1999

▲ **GULLIES ON MARS,** located on the south-facing wall of an impact crater near 54.8° south latitude and 342.5° longitude, were photographed by the Mars Orbiter Camera onboard the Mars Global Surveyor on July 3, 1999. Liquid water may have carved the gullies on the slopes of various craters, troughs, and other depressions on the Red Planet. Similar landforms on both Earth and Mars are divided into three parts: the alcove, the channel, and the apron. The alcove forms above the site of water seepage; the channel forms from water and debris running down the slope; and the apron is the down-slope deposit of ice and debris. NASA/JPL/MALIN SPACE SCIENCE SYSTEMS

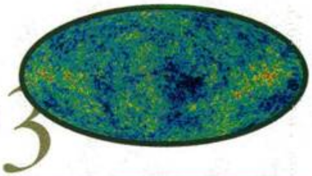
► **EINSTEIN'S CROSS** (G2237+0305) is a stunning example of gravitational lensing. The four outer images are formed by a single distant quasar whose light is bent around the nucleus of a massive foreground galaxy. For this effect to be seen, the alignment of Earth, galaxy, and quasar must be exact. Einstein's Cross, so named because Einstein predicted this phenomenon, lies in the constellation Pegasus. The distance to the lensing galaxy is 400 million light-years, but the quasar (of which we see four images) lies 8 billion light-years away. J. RHOADS, STScI, WIYN, AURA, NOAO, NSF

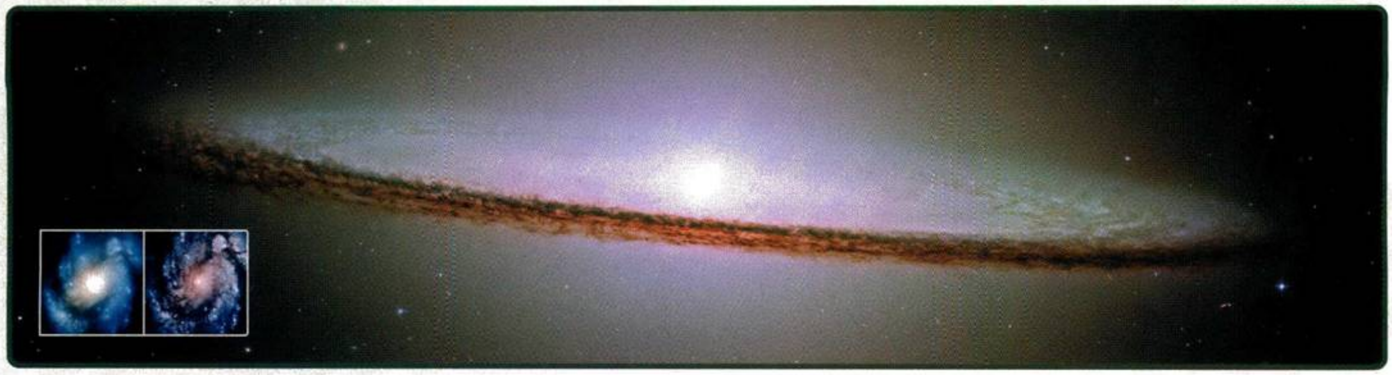
1999



► **THE EARLY UNIVERSE,** only 380,000 years after the Big Bang, was captured in the best detail yet last year by the Wilkinson Microwave Anisotropy Probe (WMAP). The WMAP image reveals 13 billion-year-old temperature fluctuations (shown as color differences) that correspond to the seeds that grew into the galaxies present today. NASA/WMAP SCIENCE TEAM

2003





▲ **FUTURE ASTRONOMICAL IMAGES** will be better than any we've seen so far. The Sombrero Galaxy (M104) in Virgo is an example; six images from the Hubble Space Telescope (HST) were combined to make this mosaic. Astronomers estimate M104, which lies 28 million light-years away from Earth, has 800 billion stars and almost 2,000 globular clusters. *Inset:* **SUCCESS** was the word used to describe the first repair mission to the HST in 1993. Before the complex mission, undertaken by the crew of the space shuttle Endeavor, Hubble suffered from poor vision due to a slightly misshapen mirror. Compare its pre-repair view of the center of spiral galaxy M100 (left) with the post-repair image (right), taken by the newly installed Wide Field and Planetary Camera 2. NASA

future

{ PLANETARY SCIENCE }

On the trail of

A hypothetical population of asteroids inside Mercury's orbit could provide a treasure trove of information about the solar system's early history. /// BY S. ALAN STERN

"Vulcanoids, isn't that something from *Star Trek*?" I can't count the number of times I've been asked that since I became interested in settling a nagging question: Does our solar system contain a population of small bodies revolving around the Sun in tight orbits interior to Mercury?

In reality, however, neither Vulcanoids themselves (if they exist), nor their name, has any lineage from *Star Trek*. In fact, *Star Trek* creator Gene Roddenberry borrowed the name for Mr. Spock's red-sky home world *from* the fabled and all but forgotten phantom planet in our solar system, called Vulcan.

Some 19th-century astronomers thought they had spied Vulcan, named after the Roman god of fire and metallurgy, near the Sun during total solar eclipses. But photographic searches early in the 20th century firmly disproved the existence of Vulcan, which was purported to be a body hundreds or thousands of miles across. By contrast, *the Vulcanoids* — a repeatedly hypothesized population of small asteroids only a few miles in diameter — might really exist.

Why should astronomers care if Vulcanoids exist? For one thing, we want to understand the geography of our solar system. Just as we want to know how many planets orbit the Sun and where they travel, we also want to learn where all the reservoirs of small bodies — comets, moons, meteoroids, and asteroids — lie and how the populations of these reservoirs compare.

For another thing, Vulcanoids could be made of the material that composed the innermost portion of the solar nebula, from which the planets formed. So if we find Vulcanoids, their study could offer important clues both to the composition and thermal conditions of the inner nebula and potentially shed light on the material from which Mercury formed. Even beyond these motivations, the detection of a significant population of Vulcanoids could provide insights into the history and chronology of the bombardment of the inner solar system by small bodies.

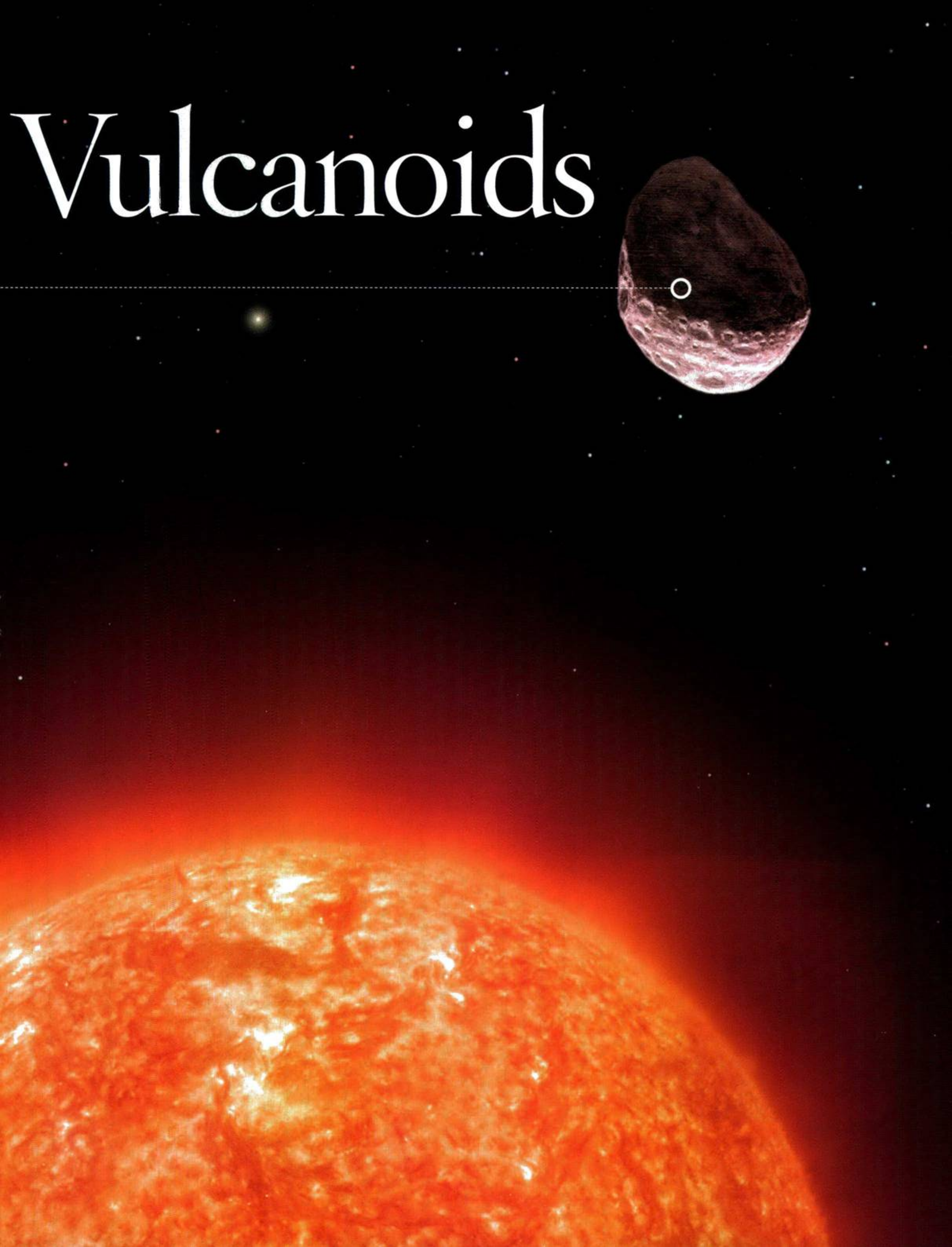
Although detecting Vulcanoids would prove scientifically valuable, do astronomers have any basis for thinking Vulcanoids actually might exist? Several separate lines of reasoning suggest the chances are good.

First, planetary astronomers who looked hard enough eventually discovered objects in every place of the solar system where theorists determined stable orbits could exist. The most recent examples of such finds include Kuiper Belt objects (denizens of the outer solar system that orbit beyond Neptune); the tiny, irregular satellites of Jupiter; and just last year, the first Trojan asteroid of Neptune (which follows Neptune's orbit around the Sun but travels 60° ahead of the planet).

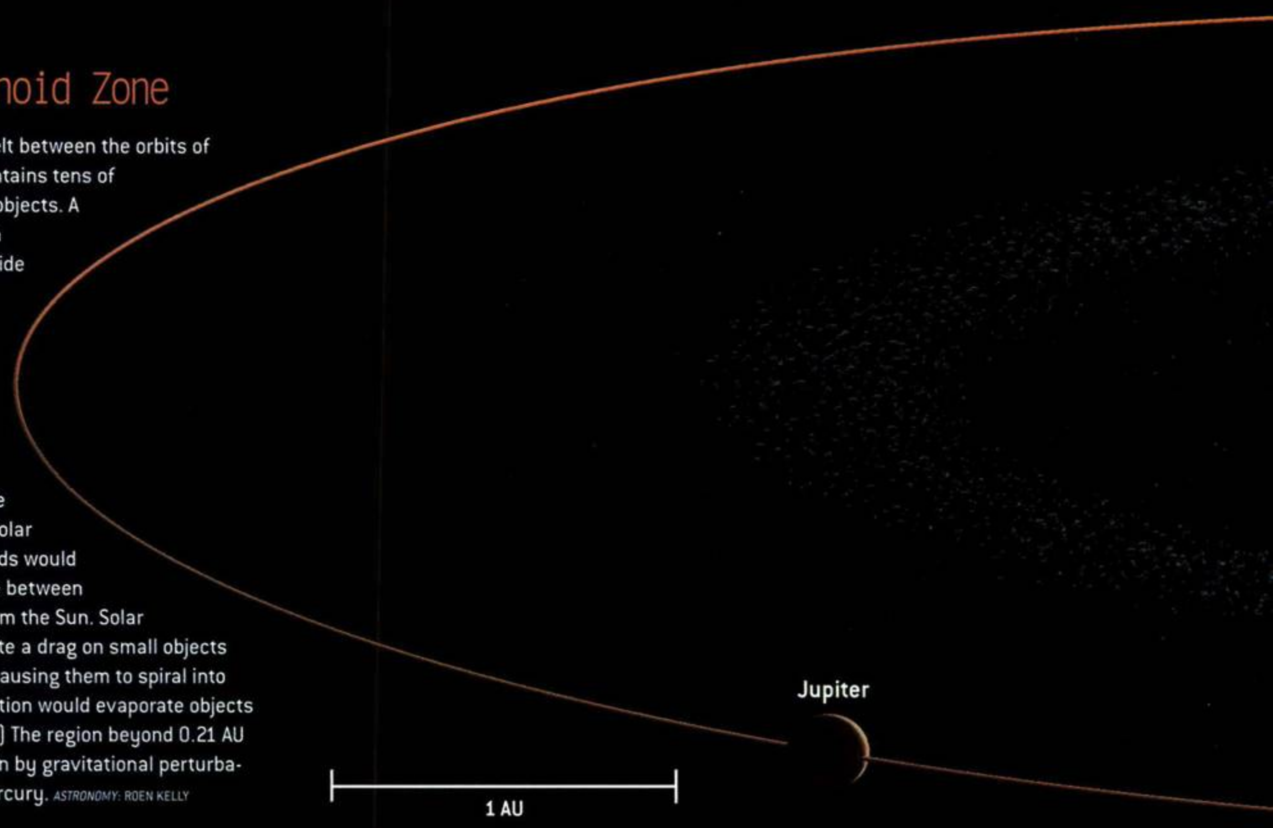
Theorists have shown that a stable region lies inside Mercury's orbit. In the late 1990s,

ORBITING INSIDE MERCURY'S ORBIT, a hypothetical Vulcanoid basks in the intense solar heat. An entire zone of such small, rocky objects may exist. ILLUSTRATION BY DAN DURDA

Vulcanoids



The Vulcanoid Zone



The main asteroid belt between the orbits of Mars and Jupiter contains tens of thousands of rocky objects. A smaller zone of such objects may lurk inside Mercury's orbit. Named Vulcanoids, these objects could offer vital insights into the bombardment history of the inner solar system and the composition of the solar nebula. The Vulcanoids would lie in the stable zone between 0.08 and 0.21 AU from the Sun. Solar radiation would create a drag on small objects located any closer, causing them to spiral into the Sun. (Solar radiation would evaporate objects closer than 0.06 AU.) The region beyond 0.21 AU would be swept clean by gravitational perturbations induced by Mercury. ASTRONOMY: ROEN KELLY

astronomers David Vokroulicky, Serge Tabachnik, and Wyn Evans modeled the inner solar system and found that the stable region extends from about 0.08 astronomical unit out to around 0.21 astronomical unit from the Sun. (One astronomical unit, or AU, is the average distance between the Sun and Earth, about 93 million miles.) Objects in this safe haven, known as the Vulcanoid Zone, would have orbits that are neither too close to the Sun, where solar radiation induces a drag that causes objects to spiral into the Sun, nor too close to Mercury, where gravitational interactions each time an object nears the planet prevent stable orbits.

Mercury
hot pixel

SOHO CORONAGRAPHIC IMAGES reveal the motion of Mercury, but they don't go faint enough to show any possible Vulcanoids. NASA

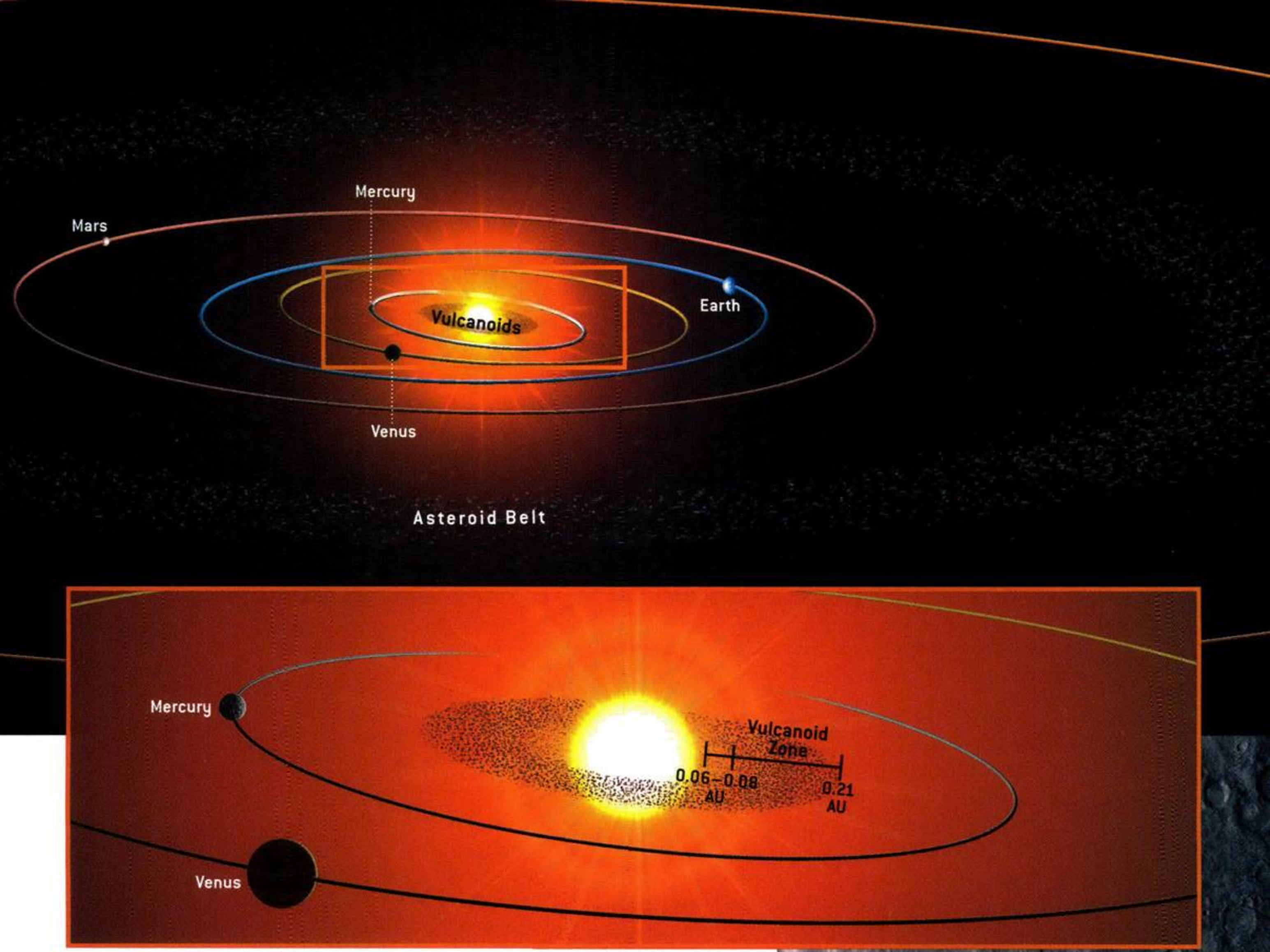
The mere existence of a stable region for orbits between the Sun and Mercury doesn't prove any objects reside there, of course. The second line of evidence that motivates the search for Vulcanoids comes from images of Mercury taken thirty years ago by NASA's Mariner 10 mission. The images show a surface covered with impact craters. Many or even most of the objects that created those craters must have come from the part of the solar system where Mercury orbits, suggesting that even if no Vulcanoids exist today, there certainly must have been some in the distant past.

These facts establish that Vulcanoids used to roam the inner solar system, and that a significant piece of real estate in the same neighborhood could provide stable orbits for them today. A few years ago, my colleague Dan Durda and I set out to see whether any of the ancient Vulcanoids could have survived to the present. We used computer models to calculate the rate of collisions in the Vulcanoid Zone as a function of the number of bodies there and their orbital properties. From those results, the models determined how these collisions would whittle down any given Vulcanoid population. Durda and I found that as many as a few hundred ancient bodies could still reside in the Vulcanoid Zone after 4.5 billion years of solar system history. That's yet another indication that a search for Vulcanoids could prove fruitful.

Devil in the details

Because Vulcanoids would lie so close to the Sun (less than about 0.2 AU away) and relatively near Earth (roughly 1 AU away), even small ones would be fairly bright. For example, a Vulcanoid 3 miles (5 kilometers) in diameter located in the middle of the Vulcanoid Zone would have a visual magnitude of 12.5, assuming its surface reflects the same percentage of sunlight as Mercury's. Virtually any amateur astronomer operating a telescope equipped with a CCD camera could detect such an object, were it not for one pesky detail: By virtue of their proximity to the Sun, Vulcanoids can be glimpsed only during twilight, when the Sun lies below the horizon but they do not.

Finding Vulcanoids under these conditions is extremely difficult. The inner boundary of the Vulcanoid Zone lies just 0.08 AU from the Sun. Viewed from Earth, this corresponds to a maximum solar elongation angle of just 4°. Even the zone's outer boundary, at a solar distance of 0.21



AU, yields an elongation of only 12°. This means any search must take place at dawn or dusk, which translates to a short observation window and a battle against the haze and turbulence so common when looking through the twilight sky. If you think spotting Mercury is hard, imagine searching for an object 40,000 times fainter lurking even closer to the horizon.

Consequently, only a few ground-based searches have been conducted in the past century. Probably the narrowest searches prior to last year were those of Henry Courten and his collaborators in the mid-1970s. They searched only during the brief moments of darkness that occur in a total solar eclipse. But during such an eclipse, the sky near the Sun grows much darker than it does at twilight, and observers usually don't have to peer through as much of Earth's atmosphere.

Unfortunately, given the 1970s-era photographic equipment they had available, and the short duration of an eclipse, Courten's team could spot only objects brighter than magnitude 8.5, which corresponds to bodies with diameters larger than about 18 miles (30 km). So, as clever as this search strategy was, Courten's team did not find any Vulcanoids.

Since Courten's work, other ground-based observers have looked deeper but were able to search only tiny fractions of the Vulcanoid Zone. As a result, the possibility of a belt of Vulcanoids has never been ruled out.

In 1999, when my colleagues at the Southwest Research Institute and I became interested in hunting for Vulcanoids, we decided to beat the chief problems encountered while observing during twilight or eclipses by going to high altitude. There,

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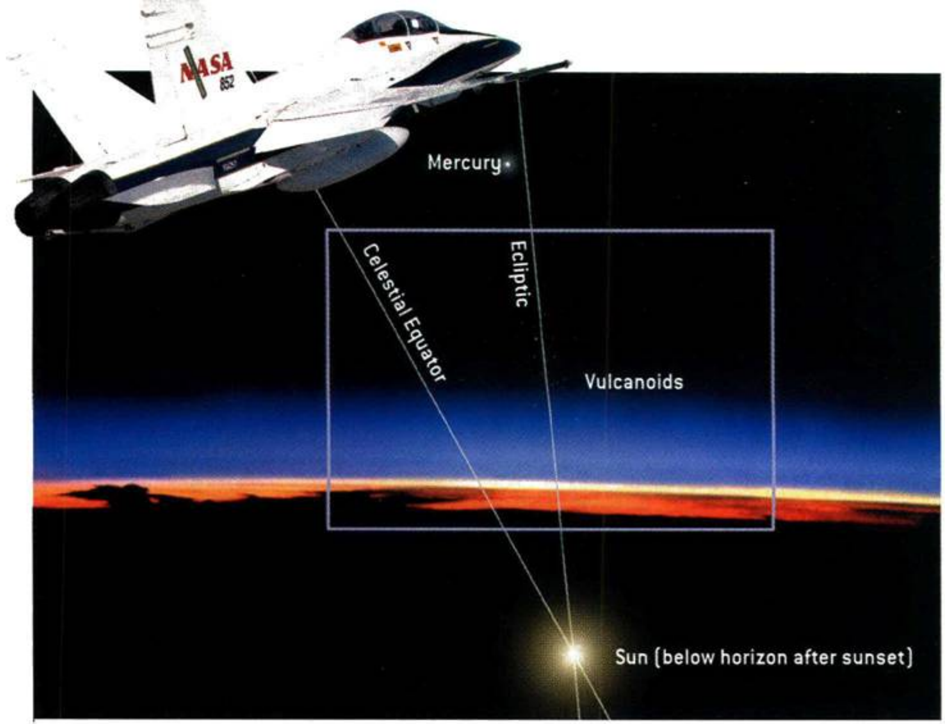
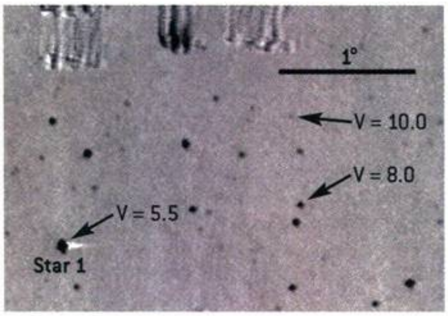
S. Alan Stern *is a planetary scientist, pilot, and author. His latest book,* Worlds Beyond, *was published in 2003 by Cambridge University Press.*

HEAVILY CRATERED MERCURY suggests that Vulcanoids, even if they don't exist today, once pummeled the inner planet's surface. NASA/JPL



THE SEARCH FOR VULCANOIDS can take place only when those objects lie well above the twilight horizon. That happens when the ecliptic — the plane of the solar system that includes the Vulcanoid Zone — makes a steep angle to the horizon, as it does after sunset in early spring. An F-18 (inset) carried the author and an advanced camera to 49,000 feet. ILLUSTRATION BY DAN DURDA; NASA PHOTO BY LORI LOSEY



THE SWUIS-A DIGITAL IMAGING SYSTEM (top) was installed in the rear cockpit of a NASA-owned F-18 aircraft. NASA PHOTO BY TONY LANDIS

A SWUIS-A IMAGE (above) of a region near the Sun shows objects down to 11th magnitude. Unfortunately, no Vulcanoids were discovered in more than 200,000 images. DAN DURDA

the sky is far darker, and haze and atmospheric thickness are not significant factors.

We began by making a computerized search of several thousand archived images taken by the Solar and Heliospheric Observatory (SOHO) satellite. We examined a sequence of white-light coronagraphic images obtained approximately every 1.6 hours by SOHO's widest field coronagraph, called LASCO C3. Each of these images covers approximately 153 square degrees of sky centered on the Sun and extends along the ecliptic out to about 30 solar radii (0.14 AU) in the heart of the Vulcanoid Zone.

Unfortunately, the LASCO instrument's detection limit for moving objects, 8th magnitude, didn't allow us to probe any deeper than the decades-old work of Courten's team. As a result, we didn't detect any Vulcanoids in the SOHO images, although we did re-discover some bright asteroids that passed through LASCO's field of view.

To make a more sensitive search, Durda and I next went back to our roots. We flew our wide-field, image-intensified SWUIS-A camera system for airborne astronomy aboard high-performance NASA aircraft. Previously, we had used SWUIS-A aboard similar jets to record occultations of stars by asteroids and to study Comet Hale-Bopp and Leonid meteors.

After NASA approved and funded this project, we conducted a series of twilight missions in 2001 and 2002, flying 49,000 feet above the Mojave Desert in an F-18 aircraft. At that altitude — the F-18's service ceiling for cruise flight — twilight is about twenty times darker than on the ground. That greatly improved the Vulcanoid search depth, which in turn allowed us to look for fainter and smaller Vulcanoids.

While NASA test pilots kept the aircraft on course, we (individually in different flights) used our deep-imaging cameras to survey about 40 percent of the Vulcanoid Zone down to 11th magnitude. This past spring, we completed our analysis of the more than 200,000 sky images taken during the flights. Our result: If Vulcanoids larger than about 6 miles (10 km) across exist, they are very rare — no more than a few handfuls can exist.

They can run, but cannot hide

Our F-18-based observations made with the SWUIS-A imaging system resulted in the most comprehensive search yet conducted for Vulcanoids. However, just because there can't be more than a small number of 6-mile-wide Vulcanoids doesn't settle the issue of whether a Vulcanoid belt exists. To do that, we need to probe down to sizes at least ten times smaller. (Any objects below this size would be affected far more by radiation drag, causing them to spiral into the Sun relatively quickly.)

Fortunately, the SWUIS-A instrument itself is capable of doing far better, imaging objects almost as faint as 14th magnitude. But to accomplish this, we need a darker twilight than even an F-18 can deliver.

Putting SWUIS-A aboard the space shuttle or space station would afford us the kind of dark sky we want. Unfortunately, the shuttle and space station fly through twilight in about two minutes, so they are comparatively poor platforms for surveying the large area of the Vulcanoid Zone. We estimate it would take hundreds of orbits to search the entire region properly.

So what's next? We will be using high-altitude balloons and suborbital rockets to fly SWUIS-A even higher. If these flights are successful, we either will have discovered Vulcanoids or ruled out anything larger than perhaps 1 kilometer in diameter.

The Vulcanoid Zone is the terra incognita of the inner solar system. It has both high scientific value and the allure of discovery that makes astronomy so much fun for us all. We're still hot on the trail of Vulcanoids — stay tuned. ■

To learn more about the Vulcanoid search, visit www.astronomy.com/toc

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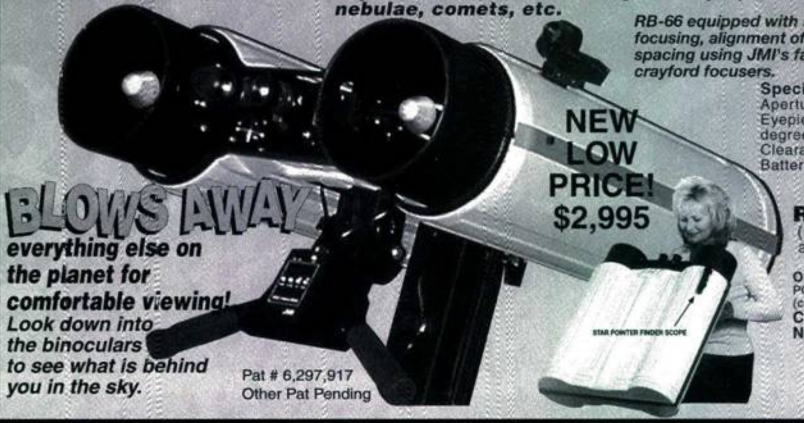

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Star light,

The supernova of A.D. 1006 was the brightest in history, and its appearance was noted worldwide. But only now are astronomers figuring out exactly what everyone saw. /// BY FRANCIS REDDY

Nearly a thousand years ago, the sudden appearance of the brightest star in history puzzled and frightened sky-watchers around the world. The new star of 1006 was a nearby supernova, the visible display of a star's complete destruction. At peak brightness, the supernova outshone Venus and even briefly rivaled the Moon. Just how bright it was, however, has been a major puzzle. Modern-day brightness estimates range more than three magnitudes, or a factor of fifteen. Recently, however, a team led by Frank Winkler of Vermont's Middlebury College observed the expanding blast wave and its interaction with the space around it. From this the team found the supernova's peak brightness, while drawing a convincing picture of how this massive star died.

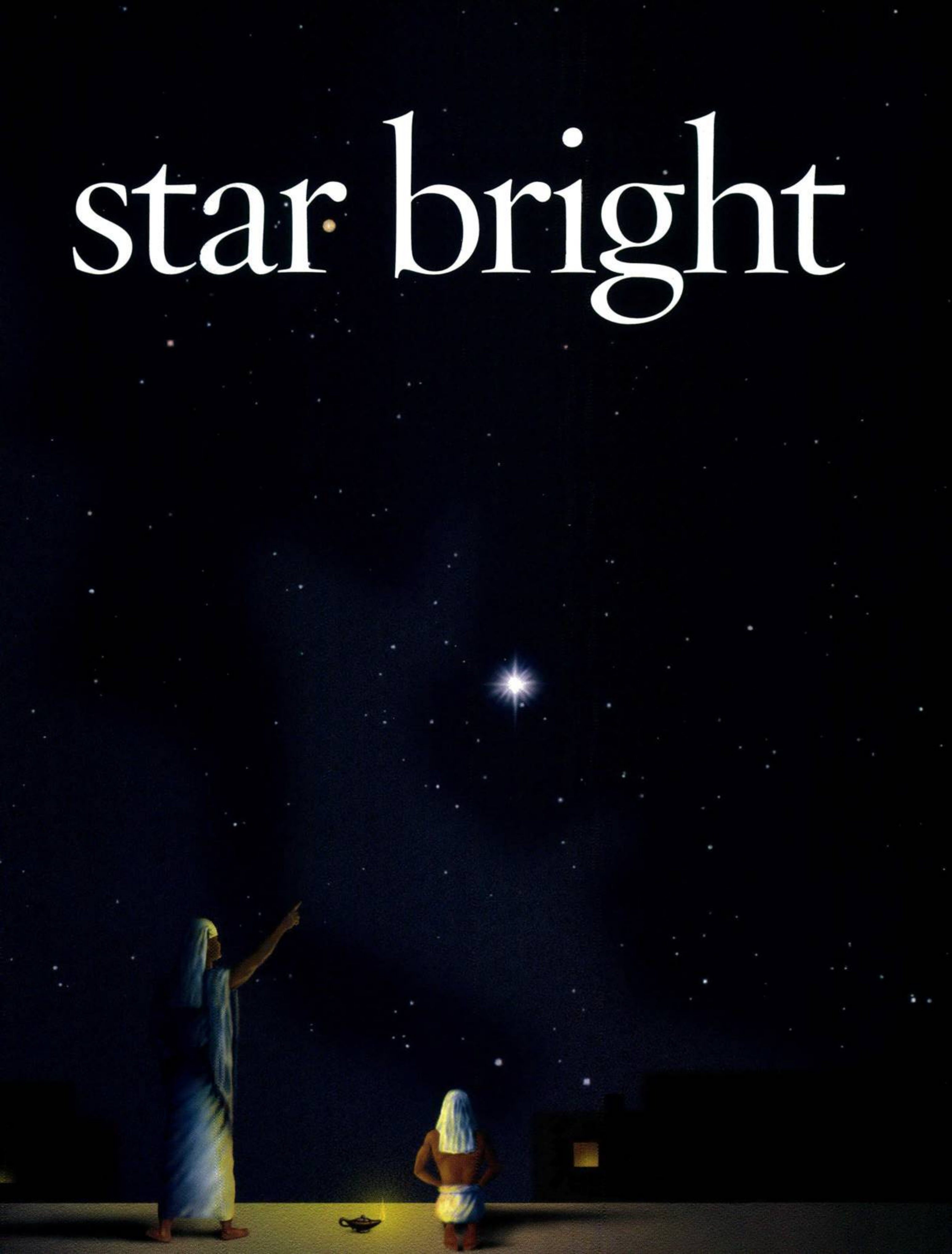
A supernova explosion radiates so much energy — more than 5 billion times the annual output of the Sun — that it outshines, briefly, the entire galaxy in which it occurs. Such an explosion transforms a star into a shell of hot gas that initially expands at speeds of 6,000 miles (10,000 kilometers) per second or more. The kinetic energy contained in this expanding shell is ten times the energy radiated in the blast. By the time a supernova reaches maximum brightness, about two weeks after the bang, our planetary system would fit inside the shell easily. Stellar debris races into the interstellar environment, creating a shock wave that compresses and heats any gas it plows into. The shock expands for many thousands of years, ultimately affecting a bubble of space more than a thousand light-years across before it loses its identity in the thin matter drifting between the stars.

On May 1, 1006, observers around the world noticed a brilliant new star in the constellation Lupus. Historians have found accounts of the event in Egypt, Iraq, Italy, Switzerland, China, and Japan, and additional references may exist in France and Syria. The most detailed account comes from Egyptian physician and astrologer, Ali ibn Ridwan (998–1061), who saw the event as a child of eight. His narrative, based on records by older observers, described the star as "a large circular body, two and a half to three times as large as Venus." The sky, he wrote, was shining because of its light, while its intensity was "a little more than a quarter that of moonlight."

Ibn Ridwan gave the positions of the Sun, Moon, and planets when the star first appeared, which helped establish the date. He noted that the star disappeared when the Sun came within 60° of its position. That corresponds to a visibility period of about three months. From his site in al-Fustat, now within modern Cairo, the star was above the

A NEW STAR BLAZED on the night of May 1, 1006. The observations of Arab astronomers helped modern astronomers fix the supernova's location — but raised questions about how bright it actually shone. JAY SMITH

star bright



horizon only during the day by the time it disappeared from sight. Because Venus at its brightest can be seen by day, this suggests the star was fainter than Venus.

Astrologers in Europe and Asia also noticed the new star. A significant observation comes from the Benedictine monastery at St. Gallen in Switzerland. Its chronicler noted "a new star of unusual size appeared, glittering in aspect, and dazzling the eyes, causing alarm. . . . It was seen likewise for three months in the inmost limits of the south, beyond all the constellations which are seen in the sky."

To modern astronomers, the implication that the star was just barely above St. Gallen's mountainous southern horizon helped pinpoint its location.

In China, the blazing star raised fears that it portended warfare and ill-fortune. Chinese astrologers watched it for three months before it disappeared into the Sun's glare, which agrees with other reports. Yet they went further: According to the records, the imperial sky-watchers recovered the star as it emegred from the Sun's glare in December 1006 and monitored it for another year and a half.

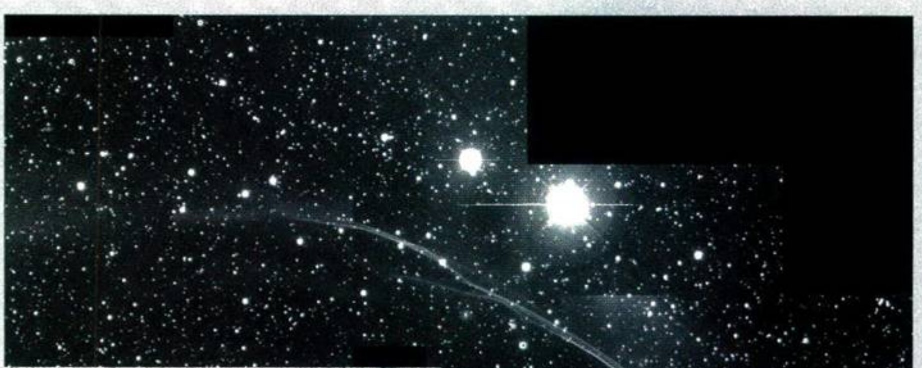
Unusual afterglow

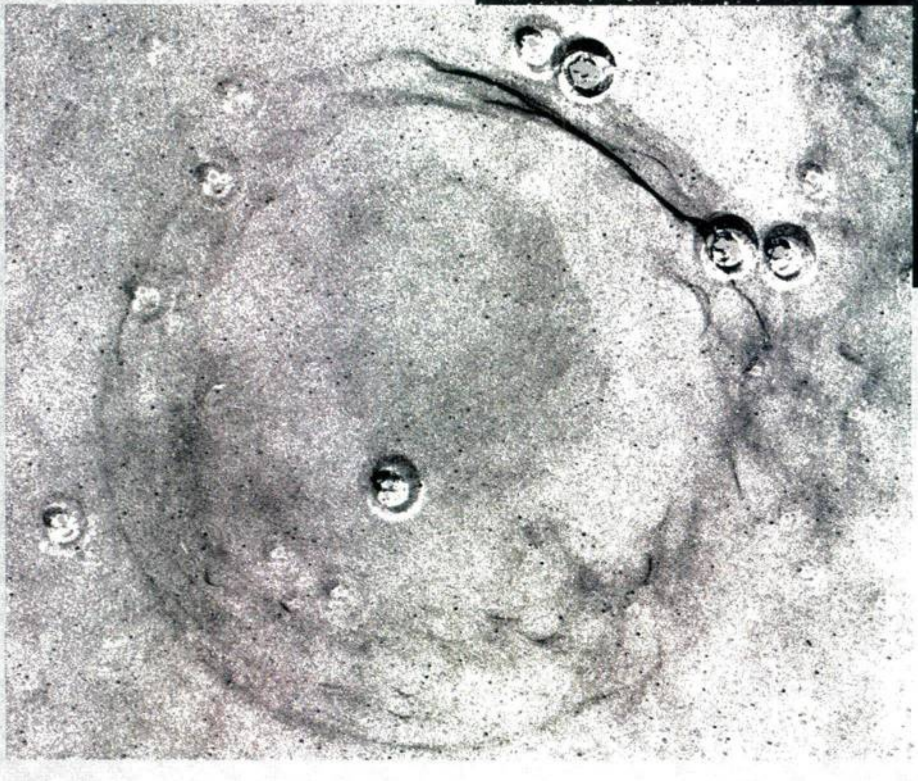
Despite the supernova's brilliance, modern astronomers couldn't locate the site of the explosion until 1965, when radio surveys turned up a potential source. It is a bubble of million-degree gas about the apparent diameter of the Full Moon. At radio and X-ray wavelengths, it resembles a ring. This phenomenon, called limb brightening, occurs because our line of sight intersects more hot gas along the shell's edge than through the middle. Like many shell-type supernova remnants, the ring shows two bright arcs. Astronomers attribute these to asymmetries either in the interstellar environment or in the explosion itself.

Most of the radio and X-ray emission comes from the northeast and southwest arcs. In the mid-1990s, instruments on the Roentgen Satellite (ROSAT) and the Advanced Satellite for Cosmology and Astrophysics (ASCA) glimpsed remarkable processes occurring there. Speeding electrons produce a characteristic radiation called synchrotron emission when they spiral through intense magnetic fields, such as those associated with a supernova shock wave. Satellite observations of the bright arcs in the 1006 remnant revealed electrons accelerated to energies of more than 200 trillion electron volts. By comparison, that's about a billion times the energy of a medical X ray. Such dramatic accelerations support the long-held view that supernova shocks produce the hyperfast particles known as cosmic rays.

At optical wavelengths, however, the remnant looks very different — in fact, it's hardly there. A few delicate wisps of gas, prominent only in the red light characteristic of hydrogen, occur along the shell's northwest edge where radio emission is weakest. And that appears to be it.

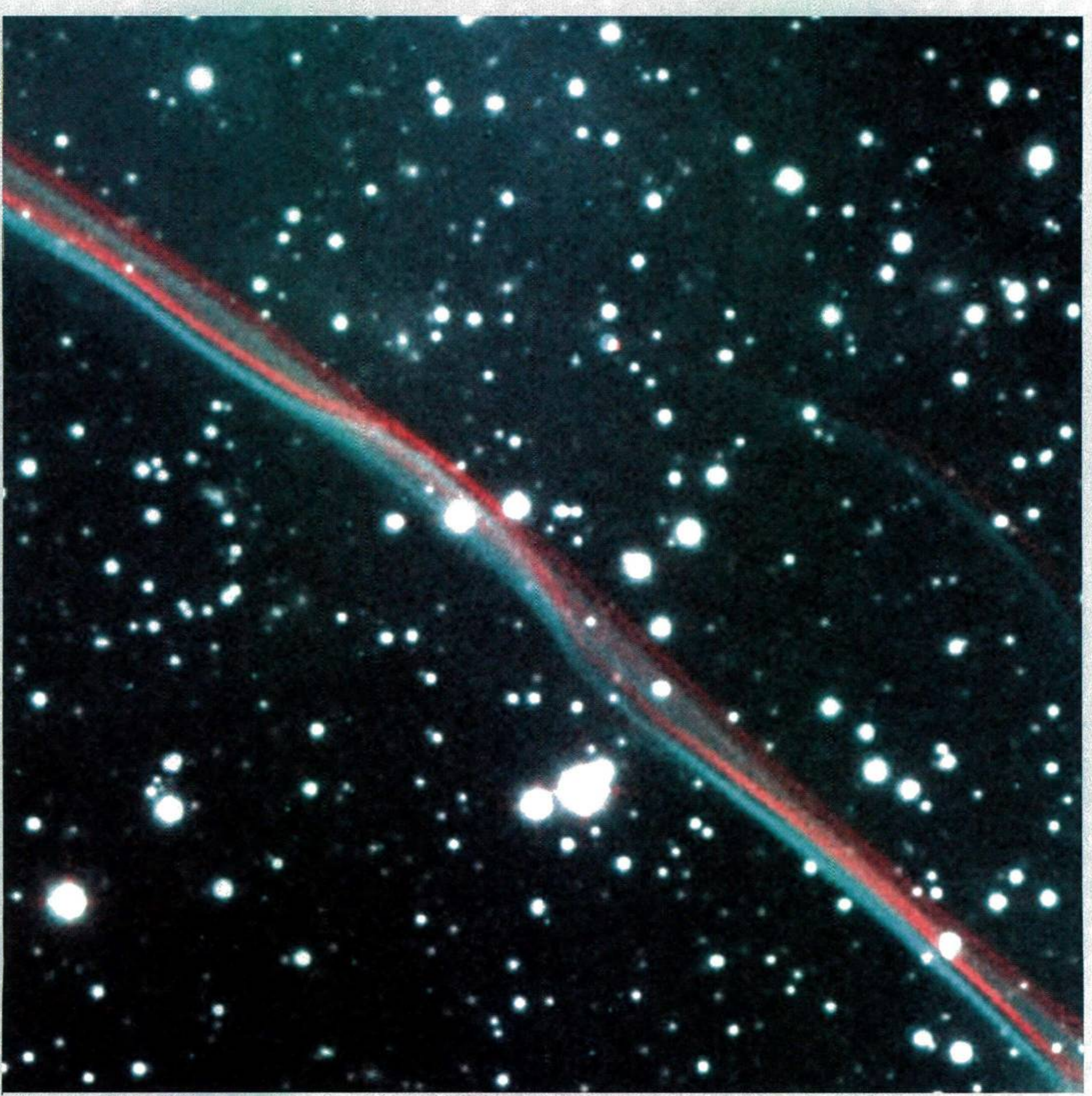
Hoping to dig deeper into why a bright supernova would leave such an optically unimpressive remnant, Frank Winkler teamed with Knox Long from the Space Telescope Science Institute to investigate.





▲ **ZOOMING IN ON THE FILAMENT** that appears brightest in visible light shows clearly where the shock wave, moving outward at more than 6 million miles per hour, is colliding with thin interstellar gas. FRANK WINKLER, MIDDLEBURY COLLEGE/CTIO

◀ **SHOOTING DEEP IN HYDROGEN LIGHT** reveals the supernova remnant's full extent — a million-degree bubble of gas appearing about as big as the Full Moon. (Image processing has left artificial patterns around all the bright stars.) FRANK WINKLER, MIDDLEBURY COLLEGE/CTIO



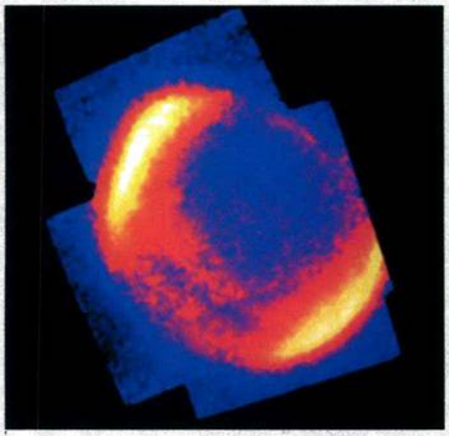
ELEVEN YEARS separate two superimposed images of the shock wave. The green image dates from 1991, the red from 2003. Note how the filament has moved outward relative to the stars seen through it. (This image also can be seen in stereo using red/green glasses.) FRANK WINKLER, MIDDLEBURY COLLEGE/CTIO/F. REDDY

"Young supernova remnants provide us with an opportunity to learn about an exploded star before its debris becomes hopelessly mixed up with the interstellar medium," Winkler says. Observations at the Cerro Tololo Inter-American Observatory (CTIO) in Chile have uncovered additional arcs of gas and a shell of faintly glowing hydrogen surrounding the spot where the star exploded. The shell forms an almost perfect circle, flattened slightly in the northwest where the brightest filaments lie. This is probably where the shock wave is encountering interstellar gas of slightly greater density.

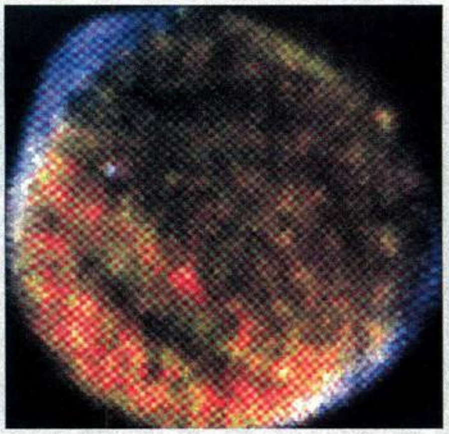
Even the remnant's spectrum looks peculiar. The visible nebulosity of most supernova remnants shows an emission spectrum from a number of elements — oxygen, nitrogen, and sulfur, as well as hydrogen. Yet the 1006 remnant glows almost exclusively in the light of hydrogen. In fact, it was only the second such remnant to be identified. (The first was the remnant from the "new star" studied by Tycho Brahe in 1572.) So what's going on?

Shocks without collisions

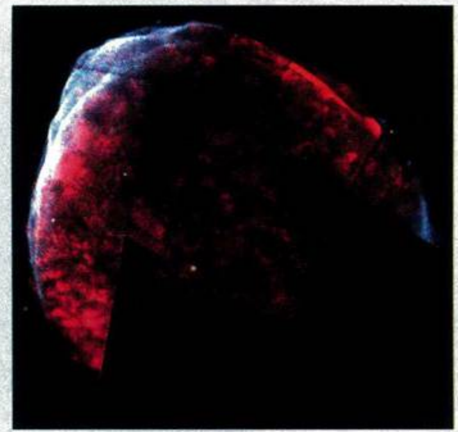
The first element to understand with the 1006 remnant is the shock wave: a hot soup of electrons and ions and their associated magnetic fields called a plasma. In this plasma, particles rarely collide with each other. Physicists call this situation a "collisionless shock." The moving shock wave of plasma slams into the electrically



YELLOW ARCS in this X-ray image show where synchrotron radiation is generating high-energy cosmic rays. ERIC V. GOTTHELF/USRA/GSFC/NASA



X RAYS SHINE BRIGHTLY from regions that appear dim optically. The radiation comes from electrons moving at very fast speeds. ROSAT/MAX-PLANCK-INSTITUT



CHANDRA'S IMAGE of the northeast rim reveals the shock wave accelerating electrons that radiate by the synchrotron process. KNOX LONG, STScI/NASA/CXC

charged particles. In a magnetic field, charged particles can move only in spiral paths, so the plasma's fast-moving magnetic field ensnares and energizes any ions and electrons it encounters.

Turbulence may drive particles repeatedly across the shock, pumping up their energy with each passing. Astrophysicists suspect this process, called Fermi acceleration, leads to the creation of high-energy cosmic rays.

The second part to comprehending the 1006 remnant is understanding the nature of the interstellar gas *outside* the shock. It consists primarily of atomic hydrogen at a temperature of about 100 kelvins. This cool neutral gas slips unaffected through the tangled electromagnetic environment at the shock, but once inside, it encounters particles with temperatures of tens of millions of degrees. Collisions with these high-energy electrons and protons ionize the neutral gas and break it apart. When energized by electron strikes, the gas emits well-defined red hydrogen spectral lines.

What makes hydrogen-dominated supernova remnants such uninteresting objects at optical wavelengths is the paucity of interstellar matter around them. The region beyond the 1006 remnant may hold as few as two atoms of neutral hydrogen in a five-cubic-centimeter volume of space. In the vicinity of bright supernova remnants like the familiar Cygnus Loop, the gas density is at least a thousand times higher. When a supernova shock slams into dense clouds of interstellar gas, it engulfs the gas and triggers a secondary shock that works its way through the cloud. This heats and ionizes the gas, which cools by radiating the energy we see.

Filaments of ionized hydrogen can occur only right at the shock front, Winkler notes, "because once the shock wave passes through, the gas no longer emits light." In fact, most supernova remnants lack any substantial visible component. Thus, the 1006 remnant is actually more typical of supernova debris than the shreds of delicate nebulosity found in the Vela or Cygnus loops.

How far?

Looking for correlations, Winkler and Long compared their optical images to radio maps and X-ray data. They found that the remnant's structural details correspond well across wavelengths, which supports the idea that the strongest emission at all wavelengths stems from shock-accelerated electrons. The peak of X-ray emission occurs just 8 arcseconds inside the brightest visible filaments in the northwest part of the ring. Spectral observations indicate the shock is moving at about 1,800 miles (2,900 km) per second — nearly one percent the speed of light — so the distance between the filaments and the X-ray peak shows that neutral gas begins to emit X rays roughly a century after the shock blows through.

The key to solving the question of how bright the 1006 supernova was, however, lies in pinning down its distance. Winkler, Long, and Middlebury College undergrad Gaurav Gupta used CCD images collected over eleven years to measure how fast the brightest filaments in the shell are expanding. They found a shift of 280 milliarcseconds per year in those places along the arc where the filaments are well defined.

The brightness and duration of the 1006 supernova suggest it was a Type Ia event. These supernovae originate in binary systems, where matter flows from a normal star and accumulates onto a white dwarf companion. The added mass ultimately destabilizes the dwarf, completely destroying it. The absolute magnitude for Type Ia events is about –19.5.

Knowing the rate at which the shell is expanding and its true velocity, Winkler's group calculated a precise distance. The result — 7,100 light-years — also must be the distance to the exploded star. "By knowing this distance and the standard luminosity of Type Ia supernovae, we can calculate, in retrospect, just how bright the star must have appeared to eleventh-century observers," Winkler says. In modern terms, the supernova shone at –7.5 magnitude, or fifteen times as bright as Venus but much less than the Full Moon's brightness (which is –12.7 magnitude.)

Ali ibn Ridwan compared the new star to both objects. "He's talking about using Venus and the Full Moon as benchmarks on a scale and is trying to describe where the star appears relative to them," says Winkler. The early evening sky of mid-May 1006 was dominated by these three objects. "It's taken a long time to interpret what he meant, but now I think we've finally got it right." ■

Explore the other historical supernovae at www.astronomy.com/toc

Francis Reddy *is a freelance writer and museum exhibit consultant. His most recent book, written with Greg Walz-Chojnacki, is* Celestial Delights: The Best Astronomical Events through 2010 *(Celestial Arts, 2002).*

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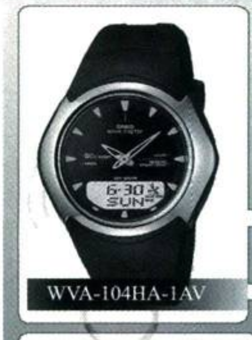

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BY MARTIN RATCLIFFE AND ALISTER LING

FEBRUARY 04

As the brightest planets begin to dominate the evening sky, no skygazer will be able to resist the beauty of this string of celestial pearls.

An evening planet extravaganza

Venus in her blazing glory adorns the southwestern sky after sunset. The planet's pure white light shines three times brighter than the ruddy beacon that was Mars late last summer. Looking through a telescope, you can feel the wonder that must have struck Galileo — Venus goes through phases like the Moon. This month, the size of the planet's disk grows while its gibbous phase wanes toward a half-Moon figure.

Mark your calendars for January 24 and February 23, when a slender crescent Moon lies near Venus. Arguably the best sight binoculars can deliver, these pairings are not to be missed. Look for earthshine filling in the rest of the Moon's shape, which is aglow in sunlight reflected off Earth. Several more conjunctions between the Moon and bright planets will take place each month until late spring.

The next pearl on the solar system string is Mars, perched high in the southwest. Enjoy what you see with the naked eye because now that Earth has run well ahead in its orbit, Mars appears as a tiny blur through earthbound telescopes. Watch, as the ancients did, how Mars advances slowly across the sky night by night, closing in on the yellow gem Saturn.

THE MOON AND VENUS pair up in the evening sky on February 23. The two will appear closer then than they did on the same date six years ago (above), when they shone at dawn. JOHN MCNEAL

In terms of sheer visual impact in the eyepiece, no sight in the heavens can match Saturn and its rings. Mars may have a solid surface and Jupiter its ever-changing clouds, but observers continually and enthusiastically return to Saturn to re-energize their souls. Once it gets dark, Saturn lies above the worst of our atmosphere's image-distorting turbulence. Check out "Saturn in prime time" in the January 2004 issue for observing tips. The Moon pairs with Saturn on both February 2 and 29.

The last pearl in our string to clear the horizon is the pale, peach-colored Jupiter. Resist the urge to observe it through our wavering atmosphere in mid-evening; wait until midnight for a good look. Any small telescope will reveal the planet's two main purple-brown belts and four Galilean moons. From night to night, the moons form different patterns. You can see all of them on one side of Jupiter on the evening of the 9th.

Of course, there isn't a real string connecting the planets, but they do seem to form a line. Imagine yourself as a grain of salt on a tabletop. If you had no depth perception, other salt grains on the table would appear to form a line. In the sky, this line is called the ecliptic and the tabletop is called the ecliptic plane.

Get ready for a comet show this spring, when two bright interlopers grace our sky. Although the brightness of a comet is notoriously difficult to predict, both should be visible to the naked eye from a dark site. The first one, C/2002 T7 (LINEAR), can be seen now in the evening sky with binoculars or a small telescope. It will disappear in the Sun's glare by mid-March, then pop up in the morning sky during April, when it should sport a lovely tail.

NEW Celestron StarBright XLT High Performance Optical Coatings Outperform The Competitor's UHTC.

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One of the most important factors in the evaluation of a Schmidt-Cassegrain telescope's optical system performance is its transmission — the percentage of incoming light that reaches the focal plane. The design of the XLT System accomplishes two crucial objectives: Develop a coating system that is optimized for visual use *and* for CCD/Photographic imaging.

Celestron StarBright XLT: The Bottom Line.

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- **11% more photons will be detected with a CCD camera using StarBright XLT coating system compared to UHTC coatings** (See Fig.#2)
- **6% brighter than UHTC to the dark-adapted eye** (See Fig.#3)
- **16% brighter than our standard StarBright coating across the spectrum from 400nm to 750nm.**

Coming Out of the Dark — StarBright XLT Performance Where It Counts

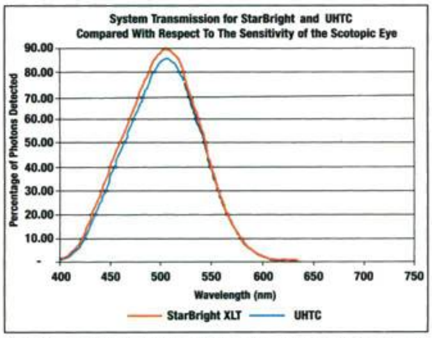

*Fig #3: The scotopic, dark adapted eye is most sensitive at about 510nm. The dark-adapted eye has nearly zero sensitivity below 400nm and above 650nm. This plot compares StarBright XLT and our measurement of UHTC taking into account the sensitivity of the human eye. The result is that StarBright XLT is a **6% improvement over UHTC** for visual observing .**

System Transmission At Specific Wavelengths — Celestron StarBright XLT vs UHTC

	Wavelength (nm)	StarBright XLT	UHTC Measured	Percent Improvement
H-beta	486	87.5	83.0	**5%**
Helium II and O_3	496	88.0	84.0	**5%**
O_3	501	88.0	84.3	**5%**
Center of dark adapted vision	510	88.7	84.8	**5%**
Helium I	588	88.0	81.6	**8%**
N_2	655	84.0	73.8	**14%**
N_2 and H-alpha	658	84.0	73.0	**15%**
Sulfur II	673	83.0	72.0	**15%**

System Transmission for StarBright XLT and UHTC

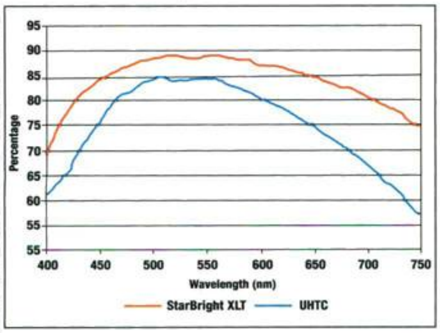

*Fig #1: This is a plot of measured system transmission for Celestron's StarBright XLT and UHTC coatings. The StarBright XLT coating has an overall average system transmission of 83.5% compared to UHTC at 75.1%. System transmission is determined by taking the measured value of the reflectance of the primary, times the reflectance of the secondary, times the transmission of the corrector lens.**

CCD Imaging — It's All In The Photons

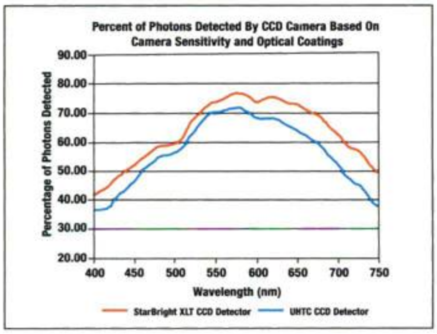

*Fig #2: StarBright XLT is not only optimized for visual use, it is also optimized for imaging. This plot takes into account the sensitivity of a popular CCD chip (KAK-3200 used in SBIG's ST10ME) in conjunction with the system transmission based on the optical coatings. Our measurements indicate that the CCD chip will detect 11% more photons with Celestron's StarBright XLT than UHTC.**

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****Percent differences are calculated by taking the comparison data percentage divided by the baseline data. Example: Measured average system transmission for UHTC is 75.1%. XLT average system transmission is 83.5%. 83.5% divided by 75.1% = 1.11 or 11% improvement. Measurement results are rounded to the nearest whole percentage.***

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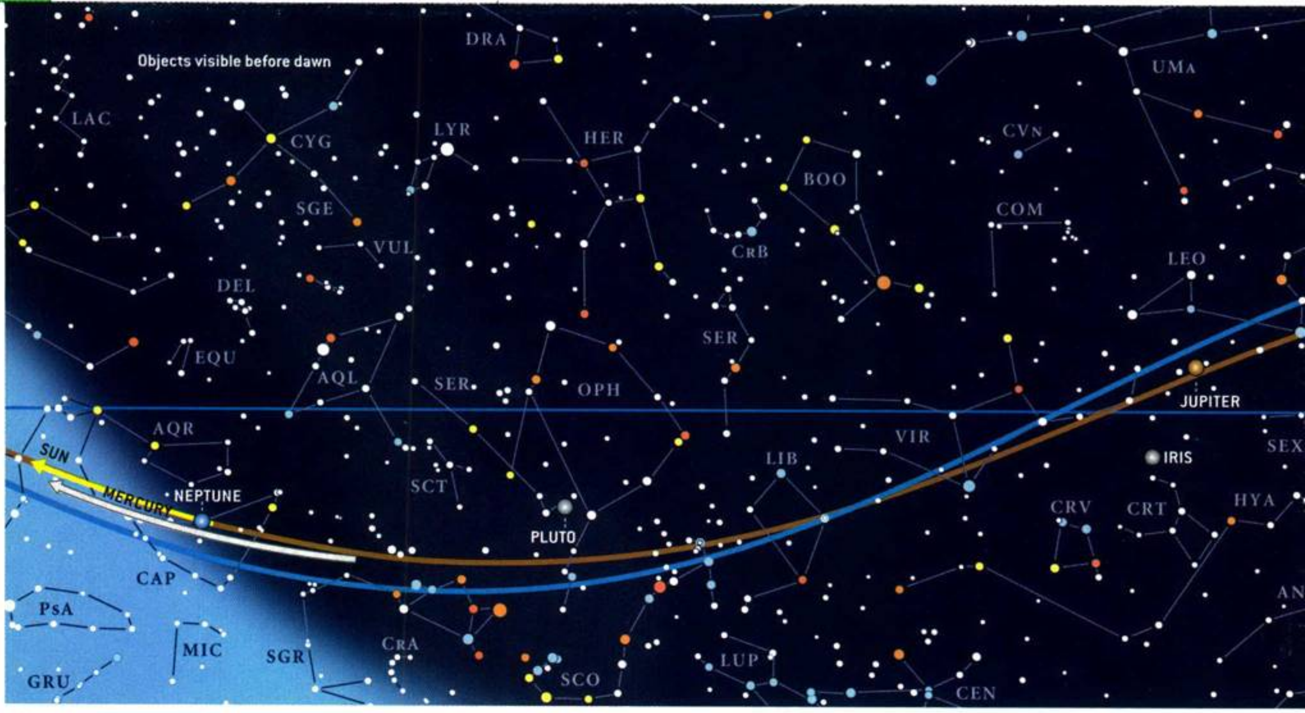
Planets this month

This map unfolds the entire night sky from sunset (at right) until sunrise (at left). Arrows and



Objects visible before dawn
DRA
UMA
LAC
CYG
LYR
HER
CVN
BOO
SGE
COM
VUL
CRB
LEO
DEL
SER
EQU
AQL
SER
OPH
JUPITER
AQR
SEX
VIR
LIB
IRIS
SUN
MERCURY
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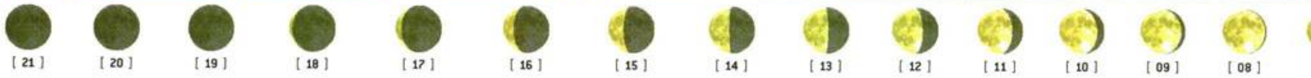

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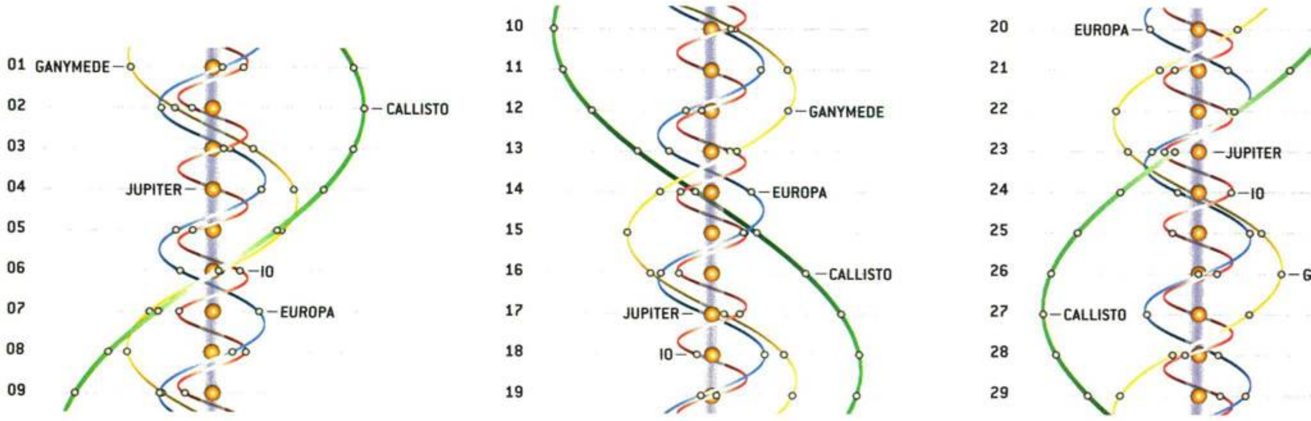
To locate the Moon in the sky, draw a line from the phase shown for th

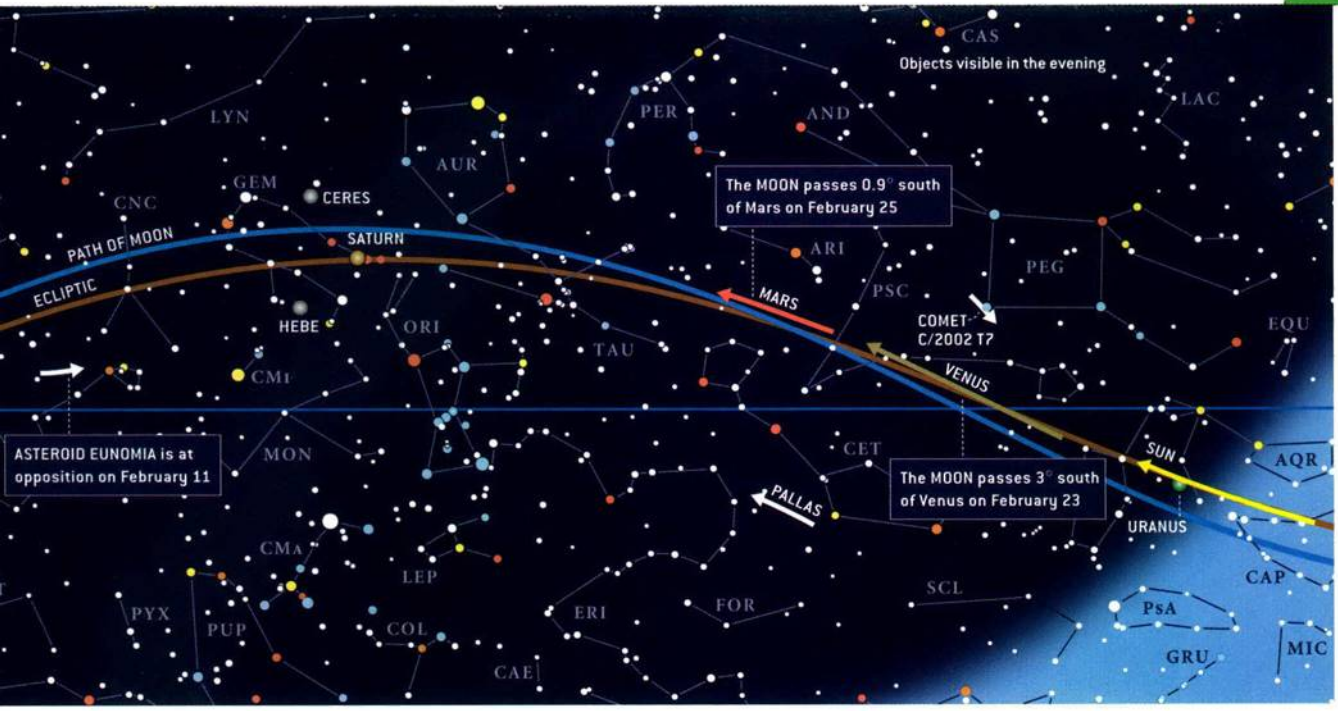
PLANETS	**MERCURY**	**MERCURY**	**VENUS**	**MARS**
Date	February 1	February 15	February 15	February 15
Magnitude	–0.2	–0.5	–4.1	0.9
Angular Size	5.5"	5.0"	16.2"	6.2"
Illumination	83%	93%	70%	90%
Distance (AU) from Earth	1.232	1.353	1.030	1.522
Distance (AU) from Sun	0.463	0.456	0.721	1.533
Right Ascension (2000.0)	19h31.0m	21h00.6m	0h27.3m	2h18.8m
Declination (2000.0)	–22°28'	–18°59'	2°48'	14°43'

Jupiter's moons

Dots display positions of Galilean satellites at 11 P.M. EST on date shown. South is at top to match the view in a telescope



colored dots show motions and locations of solar system objects during the month.


CAS
Objects visible in the evening
LAC
PER
AND
LYN
AUR
GEM
CERES
CNC
PATH OF MOON
SATURN
The MOON passes 0.9° south of Mars on February 25
ARI
PEG
ECLIPTIC
MARS
PSC
HEBE
ORI
COMET C/2002 T7
EQU
TAU
CMi
VENUS
ASTEROID EUNOMIA is at opposition on February 11
MON
CET
SUN
AQR
PALLAS
The MOON passes 3° south of Venus on February 23
URANUS
CMa
CAP
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FOR
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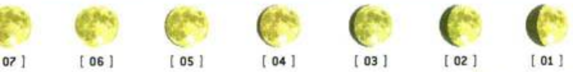
MIC
CAE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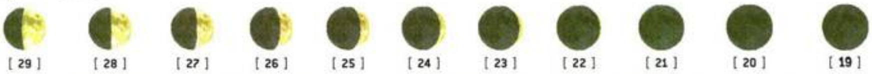
day straight up to the curved light-blue line.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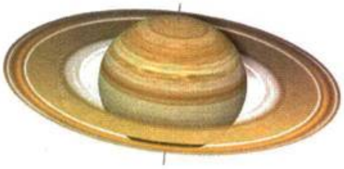
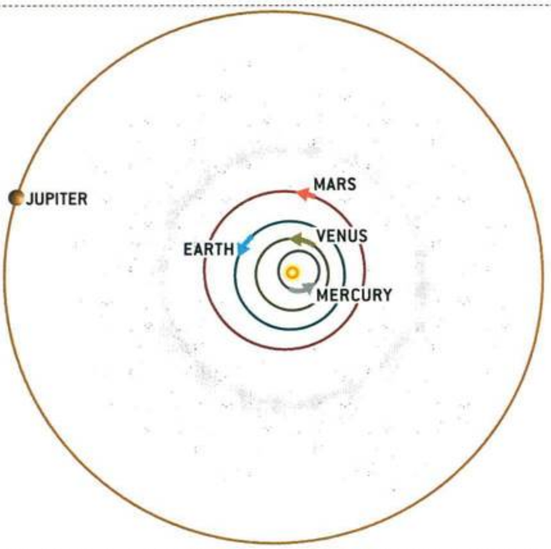
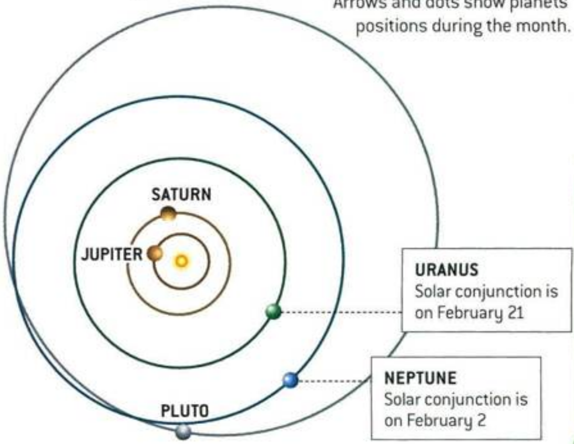


JUPITER	SATURN	URANUS	NEPTUNE	PLUTO
February 15	February 15	February 15	February 15	February 15
−2.5	−0.2	5.9	8.0	13.9
44.0"	19.9"	3.4"	2.2"	0.1"
100%	100%	100%	100%	100%
4.478	8.355	21.021	31.038	31.176
5.414	9.035	20.041	30.074	30.757
11h11.3m	6h28.9m	22h18.3m	21h03.1m	17h26.4m
6°44'	22°42'	−11°19'	−16°52'	−14°30'


JUPITER
MARS
EARTH
VENUS
MERCURY

The planets in their orbits

Arrows and dots show planets' positions during the month.


SATURN
JUPITER
PLUTO

URANUS
Solar conjunction is on February 21

NEPTUNE
Solar conjunction is on February 2

We've added a new dimension to our NexStar® GPS family of GoTo telescopes.

NexStar 11 GPS

NexStar 9.25 GPS**

NexStar 8 GPS

NOW AVAILABLE WITH
StarBright® XLT
HIGH PERFORMANCE OPTICAL SYSTEM
For more information, visit: www.celestron.com/starbrightxlt

Introducing the NexStar 9.25 GPS.

The Celestron 9.25" optical tube was already a favorite among astrophotographers and discerning visual observers, but now with the **carbon fiber tube** and the **NexStar GPS mount**, it is a formidable addition to the NexStar GPS family. The 9.25 was **specifically designed for visual infinity focus when using 2" eyepieces** and has an **optimized baffle system** to benefit astrophotography by minimizing vignetting at the edge of the field of view. Its **longer primary focal length** and **lower magnification secondary mirror** contribute to a flatter field of view at the focal plane and helps to further reduce optical aberrations. ***This feature-packed model comes standard with a carbon fiber tube and Celestron's renowned StarBright® multi-coatings.*** The NexStar 9.25 GPS is compatible with the complete line of Celestron photographic and visual accessories.

What makes the NexStar 9.25 GPS great for astrophotography?

- **Longer focal length primary and lower magnification secondary** — Contributes to a flatter focal plane with less coma and off-axis astigmatism.
- **Baffle design** — Optimized for astrophotography. Minimizes vignetting at the edge of the field of view. This reduces light drop off at the corners of your film plane.

NexStar GPS. Quality that's designed in — not added on.

NexStar GPS Standard Software Features:

- **GPS Align** – Press the Align button and the telescope will automatically begin its alignment sequence.
- **Database** – 40,000 + objects in database.
- **Magnetic North Compass Compensation** – Magnetic north and true north are not the same; magnetic north varies depending upon your position on the earth. The NexStar allows you to compensate for the variation. This improves pointing during the automated GPS alignment process.
- **Quick Align** – Gets the telescope tracking the sky without actually aligning it to two stars. Useful for tracking planets or solar observing.
- **EQ Auto Align** – The telescope will automatically pick and slew to your alignment stars even in equatorial mode.
- **Polar Alignment Routine** –The NexStar has a polar alignment algorithm making polar alignment easy and accurate for equatorial use.
- **User-defined Filter Limits** – When filter limit is set, the hand control will only display objects above the horizon or as set by the user.
- **User defined Slew Limits** – Set the maximum and minimum slew limits on the altitude axis.

Quality Components:

- Pittman Lo-Cog® brush commutated DC motors; made in U.S.A.
- 32-pitch, 5.625" pitch diameter, 180-tooth Bronze gear.
- Stainless steel worm shaft.
- Precision annealed Pyrex primary and secondary mirrors.
- **Carbon Fiber Tube** –1/4 the thermal expansion of aluminum; creates a more stable focus. The tube is four times more resistant to temperature changes than aluminum tubes; minimizes your need to re-focus.

Intelligent Design:

- Built-in 16-channel GPS receiver, magnetic compass and internal altitude switch work together to fully automate the alignment process.
- **Internal Slip Ring** – Eliminates power cable wrapping.
- **Auxiliary ports are located on the rotating base** – Auxiliary port rotates with the telescope; vastly improves cable management.
- **Ergonomic design** - Carrying handles strategically placed for improved lifting power and stability; hand control integrated in fork arm for ease of use whether on the scope or in your hand.
- **Optical Tube Assembly Mounting Rails** – An outer rail on each side of the optical tube provides rigid, flex-free movement.
- **Unique roller bearing and shaft design** – The telescope base rotates around a wide 9.5" track for maximum stability; especially important when equatorially mounted for imaging.

Standard Equipment & Specifications

	NexStar 8 GPS	NexStar 9.25 GPS	NexStar 11 GPS
Eyepiece	1.25" 40mm Plössl (51x)	1.25" 40mm Plössl (59x)	1.25" 40mm Plössl (70x)
Finderscope	9x50	9x50	9x50
AC Adapter***	Included	Included	Included
Tripod	Heavy-Duty Adjustable	Heavy-Duty Adjustable	Heavy-Duty Adjustable
Fastar Compatible	Yes	No	Yes
Mirror Coatings	StarBright®, 5-step multi-layer	StarBright®, 5-step multi-layer	StarBright®, 5-step multi-layer
Telescope Weight	42 lbs	58 lbs	65 lbs.
Price*	$1999	$2699	$2999
Shipping & Handling	$95	$115	$125

NEW 2003 PRODUCT GUIDE

To request a copy of Celestron's new 2003 Product Guide, contact us at (310) 328-9560.

CELESTRON®

2835 Columbia St. • Torrance, CA 90503 U.S.A.• Tel: 310.328.9560 • **www.celestron.com**

©2003 Celestron NexStar and StarBright are registered trademarks of Celestron. Product design and specifications subject to change without notice. *Prices shown are retail mail-order and shown in U.S. Dollars.
**NexStar 9.25 GPS shown with these optional accessories: Equatorial Wedge (#93655), Radial Guider (94176), and MicroGuide Reticle Eyepiece (#94171). Camera not included. ***120V AC Adapter included for U.S.A. and Canada only.

CELESTRON

ACCESSORIES

FOR MORE INFORMATION OR TO LOCATE AN AUTHORIZED CELESTRON DEALER, VISIT: WWW.CELESTRON.COM

OMNI® Eyepieces — 1 1/4"

- Focal lengths – 4mm, 6mm, 9mm,12.5mm, 15mm, 20mm, 25mm, 32mm, and 40mm
- **4-element premium symmetrical optical design**
- Fully multi-coated
- 52º (43º for 40mm) Field of View
- 2-step anodize process to prevent reflection from top surfaces
- Blackened lens edges

NEW!

4mm	$ 44.00
6mm	$ 44.00
9mm	$ 44.00
12.5mm	$ 44.00
15mm	$ 44.00
20mm	$ 44.00
25mm	$ 44.00
32mm	$ 54.00
40mm	$ 54.00

NEW!

OMNI® Barlow Lens — 1 1/4"

- 2x
- Fully multi-coated
- Short tube design

1-1/4"OMNI Barlow............$ 47.00

X-Cel® Eyepieces — 1 1/4"

- **6-element optical design utilizing ED glass**
- Focal lengths – 2.3mm, 5mm, 8mm,10mm, 12.5mm,18mm, 21mm, and 25mm
- Fully Multi-coated. All air-to-glass surfaces have 5 layer multi-coating
- Field of view 55°
- Parfocal – little to no focusing adjustments are needed when switching from a low power to high power eyepiece
- 20mm eye relief and soft rubber roll down eyecups
- More than 25mm of clear aperture even on the high powers for comfortable high power viewing
- Each eyepiece comes with a durable plastic case

NEW!

2.3mm	$ 69.00	12.5mm	$ 69.00
5mm	$ 69.00	18mm	$ 69.00
8mm	$ 69.00	21mm	$ 69.00
10mm	$ 69.00	25mm	$ 69.00

NEW!

E-Lux® Eyepieces 2"

- Focal lengths – 26mm, 32mm, and 40mm
- 3-element optical design
- **Fully multi-coated**
- Field of View — 56° (26mm and 32mm), 50° (40mm)
- 22mm Eye Relief

E-Lux® Eyepieces — 1 1/4"

- Focal lengths – 6mm, 10mm, 25mm, and 40mm
- Traditional Plőssl optical design
- Fully-coated

2":		1-1/4":	
26mm	$ 69.00	6mm	$ 34.00
32mm	$ 69.00	10mm	$ 34.00
40mm	$ 79.00	25mm	$ 34.00
		40mm	$ 34.00

Axiom® Eyepieces — 1 1/4", 2"

- Focal lengths –
  1-1/4": 15mm, 19mm, 23mm
  2": 19mm, 34mm, 40mm, and 50mm
- **7-element optical design**
- **70° EXTRA WIDE** field of view (except 50mm)
- Fully multi-coated

1-1/4":	
15mm	$139.00
19mm	$149.00
23mm	$179.00
2":	
19mm	$189.00
34mm	$239.00
40mm	$289.00
50mm	$329.00

Ultima® Eyepieces — 1 1/4"

- **5-element hybrid optical design**
- Focal lengths – 5mm, 7.5mm, 12.5mm, 18mm, 30mm, 35mm, and 42mm
- Fully multi-coated
- Blackened lens edges

5mm	$ 79.00
7.5mm	$ 79.00
10mm	$ 79.00
12.5mm	$ 79.00
18mm	$ 79.00
30mm	$ 99.00
35mm	$109.00
42mm	$ 99.00

10mm Plössl Reticle Eyepiece — 1 1/4"

- Five-element guiding eyepiece
- Reticle pattern is a .0075" double spaced line system
- Multicoated optics for increased contrast
- Long eye relief
- High power is ideal for guiding
- 50° apparent field of view
- Optional illuminator is required

10mm Plőssl Reticle Eyepiece —11/4"............$124.00

Ultima® 2x Barlow — 1 1/4"

- **Three-element apochromatic design**
- 27mm clear aperture
- Fully multi-coated

1-1/4"Ultima Barlow.......$ 79.00

Microguide Eyepiece — 1 1/4"

- Laser-etched reticle with a built-in, battery illuminator
- Multicoated 12.5mm Abbe (4-element) Orthoscopic
- Direct guiding on stars outside the center of the field of view
- Greatly improved off-axis guiding to capture much fainter, sharply focused guide stars without reducing limiting magnitude
- Measure position angles and separation of double stars

Microguide Eyepiece 1-1/4".......$194.00

Collimation Eyepiece

- For precise collimation of Newtonians and helpful for aligning Schmidt-Cassegrains
- Fits into 1-1/4" focusers or diagonals
- Alignment is easy using the small opening on one end and thin cross hairs at the other end
- More accurate than a simple collimation Tool

Collimation Eyepiece.......$ 39.00

Radial Guider

- Use with Schmidt-Cassegrain telescopes in prime focus, deep-sky imaging or astrophotography
- Simultaneously photograph and guide through the optical tube assembly of the telescope
- Adjustable prism and rotating eyepiece collar give wider section of sky for finding a guide star
- Eliminates the problem of differential flexure

Radial Guider.......$124.00

Reducer/Corrector

- Works with all Celestron C5, C8, C91/4 , C11 and C14 telescopes
- Minimizes coma and flattens field of view for pinpoint off-axis stars
- Reduces exposure times by 60% and increases field of view
- f/6.3 for C5, C8, C91/4 and C11 telescopes and f/7 for the C14 telescope

Reducer/Corrector.......$139.00

2" Mirror Diagonal

- 2" 90° Mirror Diagonal to thread on Schmidt-Cassegrain telescopes
- Includes an adapter to use with refractor telescopes
- Includes an adapter to accept 1 1/4" eyepieces
- Multicoated mirror
- Smooth mechanics that are precision manufactured for reliability

2" Mirror Diagonal.......$ 89.00

Stereo Binocular Viewer

- Allows you to adapt two eyepieces to the telescope for simultaneous viewing (like binoculars)
- A fantastic 3-D effect when observing many celestial objects

Stereo Binocular Viewer.......$649.00

Power Tank™

- 12-volt rechargeable power supply
- 7-amp hour
- Two 12V output cigarette lighter ports
- 3V, 6V and 9V outputs for accessories
- Built-in flashlight with red filter cap
- 800,000 candle power halogen emergency spotlight
- Booster terminal on rear side
- Built-in circuit breaker for safety
- Cigarette lighter adapter included
- AC adapter included (120V-220V)

NEW!

Power Tank............$ 69.00

Vibration Suppression Pads

- Reduces vibration time by almost 100% and decreases vibration amplitude
- The pads fit between the bottom of the tripod legs and the ground

Vibration Suppression Pads (Set of 3)............$ 59.00

Contrast-Booster Filter — 1 1/4"

by Baader

- Eliminates color aberration inherent in achromatic refractor telescopes
- Eliminates the blue hue around lunar and planetary subjects
- Multi-layer coatings for 95% transmission

NEW!

1-1/4" Contrast - Booster Filter............$ 49.00

Model A — for 1-1/4" eyepieces

Model B — for backthreads of SC's

LPR (Light Pollution Reduction) Filters

- Made of high quality, flat polished optical glass
- Over 40 layers of coating
- Broadband anti-reflection coating prevents ghosting and improves contrast

LPR Filter — 1-1/4"	$ 69.00
LPR Filter Model B	$ 99.00

1 1/4" Polarizing Filter Set

- Transmits only light moving along a specific plane; increases contrast between surfaces with different planar transmissions
- Polarization effect makes blue skies a deeper blue, eliminates surface reflections and helps reduce atmospheric haze

1-1/4" Polarizing Filter Set......$ 39.00

Eyepiece Filter Sets — 1 1/4"

- An invaluable aid in planetary and lunar observing
- Reduces glare and light scattering
- Increase contrast, definition and resolution
- Lessens eye fatigue

#94119-10 (21, 80A, 15, Polarizing)	$ 44.00
#94119-20 (12, 25, 56, ND-25)	$ 44.00
#94119-30 (23A, 38A, 58, ND-50)	$ 44.00
#94119-40 (8, ND-13, 47, 82A)	$ 44.00

Night Vision Flashlight

- Two red LEDs
- Adjustable brightness
- Uses a single 9V battery (included).

Night Vision

Night Vision Flashlight.......$ 19.00

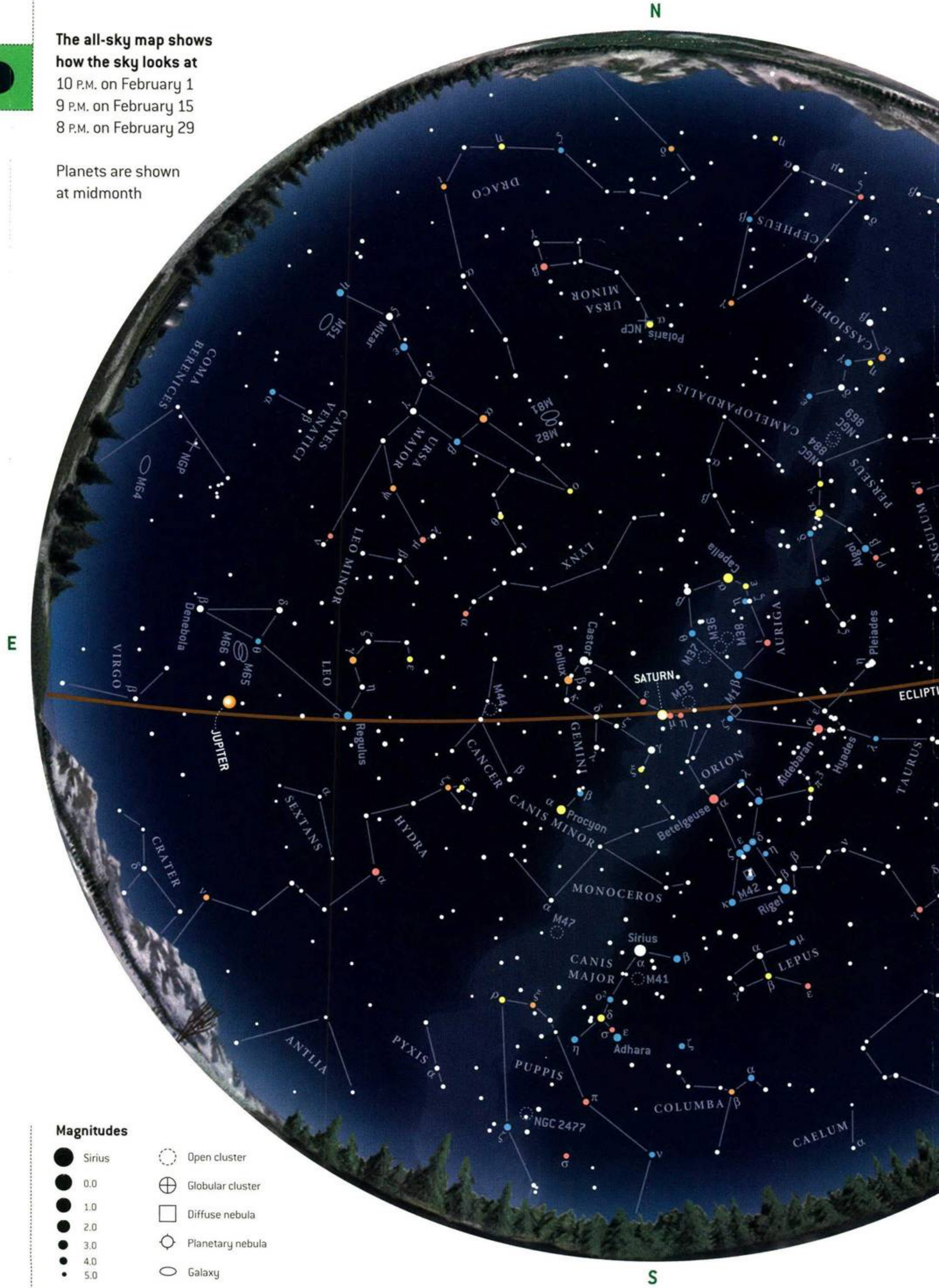
CELESTRON

2835 Columbia St. • Torrance, CA 90503 U.S.A.
310.328.9560 • www.celestron.com

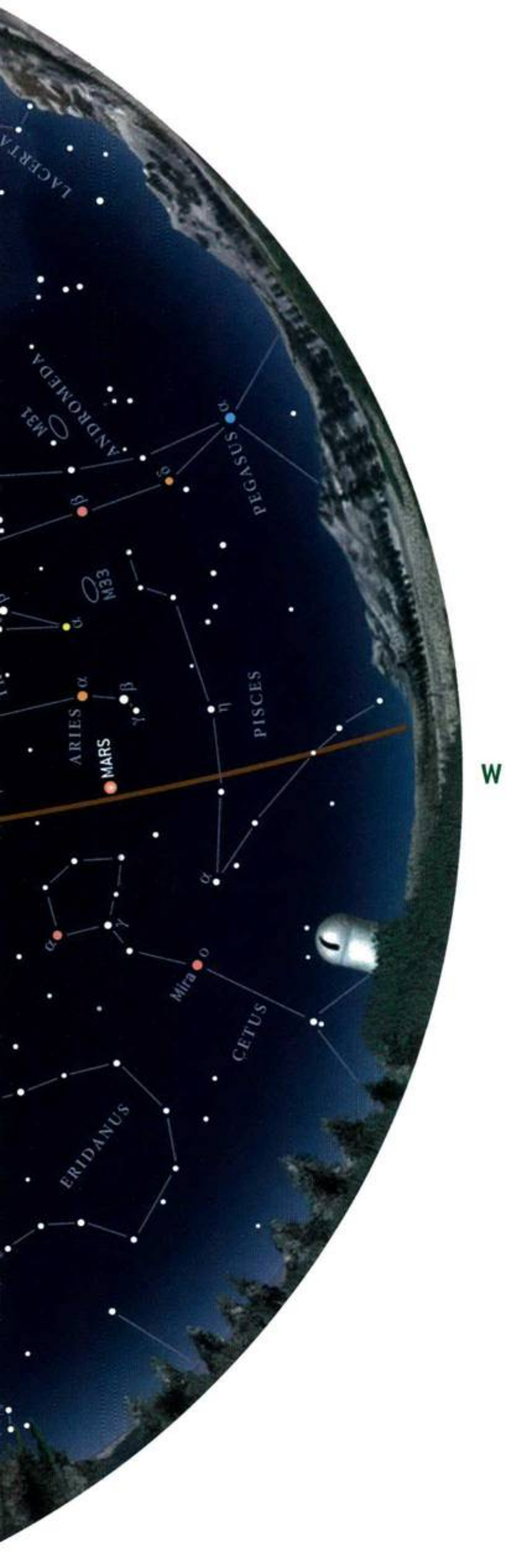
Note: All prices shown are suggested retail mail-order.
All prices shown in U.S. Dollars.

The all-sky map shows how the sky looks at
10 P.M. on February 1
9 P.M. on February 15
8 P.M. on February 29

Planets are shown at midmonth


N
E
S
DRACO
URSA MINOR
Polaris
NCP
CEPHEUS
CASSIOPEIA
CAMELOPARDALIS
NGC 869
NGC 884
PERSEUS
Algol
NGULUM
M51
Mizar
COMA BERENICES
NGP
M64
CANES VENATICI
URSA MAJOR
M81
M82
LEO MINOR
LYNX
Capella
AURIGA
M36
M37
M38
M1
Pleiades
Denebola
M66
M65
VIRGO
LEO
Castor
Pollux
SATURN
M35
M44
ECLIPTI
JUPITER
Regulus
CANCER
GEMINI
ORION
Aldebaran
Hyades
TAURUS
SEXTANS
HYDRA
CANIS MINOR
Procyon
Betelgeuse
CRATER
MONOCEROS
M42
Rigel
M47
Sirius
CANIS MAJOR
M41
LEPUS
ANTLIA
PYXIS
PUPPIS
Adhara
COLUMBA
NGC 2477
CAELUM
Magnitudes
Sirius
0.0
1.0
2.0
3.0
4.0
5.0
Open cluster
Globular cluster
Diffuse nebula
Planetary nebula
Galaxy

This map portrays the sky as seen near 35° north latitude at times shown in the upper left corner of the page. Located just outside the map are the four directions: nor
horizon, hold the map overhead and orient it so a direction label matches the direction you're facing. The stars above the map's horizon now match what's in the sky.


LACERTA
ANDROMEDA
M31
PEGASUS
α
β
β
M33
α
ARIES
α
β
γ
MARS
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PISCES
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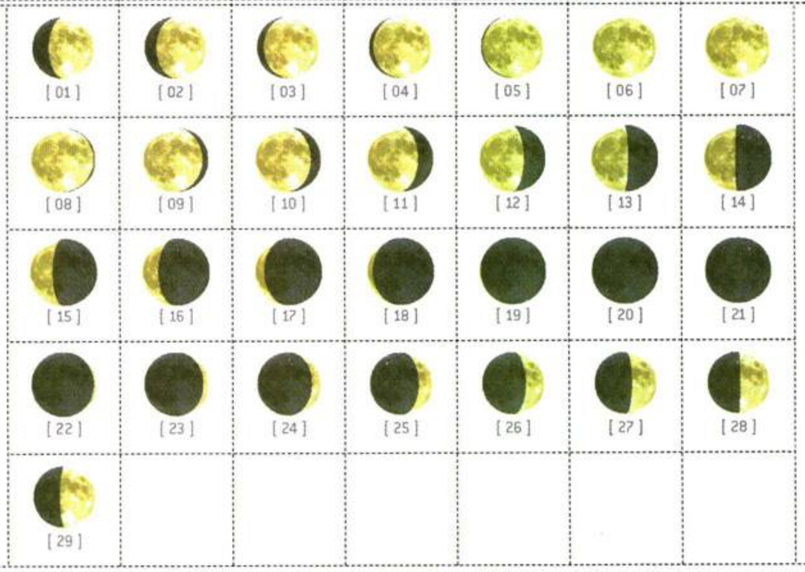
ο
CETUS
ERIDANUS
W

th, south, east, and west. To find stars above your

february 04



SUN.	MON.	TUES.	WED.	THURS.	FRI.	SAT.
[01]	[02]	[03]	[04]	[05]	[06]	[07]
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[15]	[16]	[17]	[18]	[19]	[20]	[21]
[22]	[23]	[24]	[25]	[26]	[27]	[28]
[29]						

02	Neptune is in conjunction with the Sun, 4 A.M. EST
	The Moon passes 4° north of Saturn, 11 P.M. EST
06	Full Moon is at 3:47 A.M. EST
08	The Moon passes 3° north of Jupiter, 9 A.M. EST
11	Asteroid Eunomia is at opposition, 7 A.M. EST
13	Last Quarter Moon is at 8:40 A.M. EST
15	Mercury passes 2° south of Neptune, 4 A.M. EST
16	The Moon is at perigee (228,865 miles from Earth), 2:42 A.M. EST
18	The Moon passes 5° south of Neptune, 8 P.M. EST
20	New Moon is at 4:18 A.M. EST
21	Uranus is in conjunction with the Sun, 9 P.M. EST
23	The Moon passes 3° south of Venus, 2 P.M. EST
25	The Moon passes 0.9° south of Mars, 9 P.M. EST
27	First Quarter Moon is at 10:24 P.M. EST
28	The Moon is at apogee (251,195 miles from Earth), 5:44 A.M. EST

To design the perfect telescope family for the beginner or advanced user, you have to think BIG.

C6-RGT
[#11046]

C8-S/C8-SGT/C9¼-S/C9¼-SGT NOW AVAILABLE WITH OPTIONAL

StarBright® XLT
HIGH PERFORMANCE OPTICAL SYSTEM

8" Advanced Series Schmidt-Cassegrain Products.......$125

9¼" Advanced Series Schmidt Cassegrain Products...............$175

For more information, visit:
www.celestron.com/starbrightxlt

The new Advanced Series and Advanced Series **Computerized GoTo** telescopes have been designed to offer the novice or more advanced user a selection of models with the **features, quality** and **value** that serious amateurs can appreciate. These scopes come on **NEW heavy-duty German Equatorial mounts** with **NEW ultra-sturdy 2" stainless steel legs** and center brace and accessory tray for superior stability, rigidity and vibration dampening. The Advanced Series comes in a choice of refractor, reflector and Schmidt- Cassegrain models. The refractor models range from a 4" to an impressive 6" aperture. For even more light gathering power there are 6", 8" and a **NEW 10" Newtonian** reflector. There are also 5", 8" and 9 1/4" Schmidt-Cassegrain optical designs that feature Celestron's **precision matched and hand-figured optical systems.**

Auxiliary ports for Hand Control, Dec Motor and AutoGuider.

CG-5 Mount — Precision engineered for stability.

Additional Specifications — Computerized Models

Hand Control	Double line, 16 character Crystal Display; 19 fiber optic backlit LED buttons
Motor: Type	DC Servo motors with encoders, both axes
Max Slew Speed	4°/second
Software Precision	24bit, 0.08 arcsec calculation
Hand Control Ports	RS-232 communication port on hand control
Motor Ports	Aux Port, Autoguide Ports
Tracking Rates	Sidereal, Solar and Lunar
Tracking Modes	EQ North & EQ South
Alignment Procedures	AutoAlign, 2-Star Alignment, Quick Align
Database	40,000+ objects, 400 user defined programmable objects

Our **new CG-5 German Equatorial Mount** has precision worm gears on both axes for extremely smooth tracking and slewing. The CG-5 uses large shaft and bearings and substantial base castings for additional stability. The key element that makes this system the most stable in its class is the **NEW heavy-duty tripod** with **larger and more substantial legs** that provide excellent damping characteristics for more stable views. The CG-5 also has a convenient **latitude scale** for easier alignment and an **optional polar finder scope** for the ultimate in precision alignments.

C9¼-SGT
[#11046]

GoTo convenience and GPS compatibility for precision accuracy.

We are proud to offer the GT versions of the Advanced Series on a computerized **GoTo** version of Celestron's sturdy CG-5 mount. Couple this solid mount with the included **NexStar® computer control system** and utilize many of the same features as Celestron's most advanced GoTo telescopes like an **Autoguider port** for long exposure deep sky astro-photography. **GoTo models are also upgradeable to GPS** with the optional **CN16 GPS Accessory (#93963).** It allows your telescope to pinpoint your position on the Earth, the date and time, and makes the alignment process faster and easier than ever before!

C10-NGT
[#11048]

These GoTo versions of the Advanced Series also come loaded with new software features and **over 40,000 database objects**. Capable of holding over 35 lbs of payload and slewing at 4° per second, you will be able to instantly point to any of the celestial objects in the database.

NEW 2003 PRODUCT GUIDE

To request a copy of our new 2003 Product Guide, contact us at (310) 328-9560.

Specifications — All Advanced Series Telescopes

	21016 C4-R	11071/11072 C5-S	31056 C6-N	21019/21020 C6-R	11025/11024 C8-S	31061/31062 C8-N	11045/11046 C9 1/4-S	11047/11048 C10-N
Optical Design	102mm (4.0") refractor	127mm(5") Schmidt-Cassegrain	150mm (6.0") reflector	150mm (6.0") refractor	203mm (8") Schmidt-Cassegrain	200mm (8.0") reflector	235mm (9.25") Schmidt-Cassegrain	254mm (10") reflector
Focal Length	1000mm f/10	1250mm f/10	750mm f/5	1200mm f/8	2032mm f/10	1000mm f/5	2350mm f/10	1200mm f/4.7
Finderscope	6x30	6x30	6x30	9x50	6x30	9x50	6x30	9x50
Mount	CG-4 Equatorial	CG-5 Equatorial	CG-4 Equatorial	CG-5 Equatorial	CG-5 Equatorial	CG-5 Equatorial	CG-5 Equatorial	CG-5 Equatorial
Eyepiece	1-1/4" – 20mm (50x)	1-1/4" – 25mm (50x)	1-1/4" – 20mm (38x)	1-1/4" – 20mm (60x)	1-1/4" – 25mm (81x)	1-1/4" – 20mm (50x)	1-1/4" – 25mm (94x)	1-1/4" – 20mm (60x)
Star Diagonal	1-1/4"	1-1/4"	n/a	1-1/4"	1-1/4"	n/a	1-1/4"	n/a
Accessory tray	yes	yes	yes	yes	yes	yes	yes	yes
Tripod	Aluminum	2" Stainless Steel	Aluminum	2" Stainless Steel	2" Stainless Steel	2" Stainless Steel	2" Stainless Steel	2" Stainless Steel
CD ROM	The Sky Level 1	The Sky Level 1	The Sky Level 1	The Sky Level 1	The Sky Level 1	The Sky Level 1	The Sky Level 1	The Sky L1

PRICING*: C10-NGT (#11048): $1,149 + $95 S&H; C10-N (#11047):$849 + $75 S&H; C9¼-SGT (#11046): $1,699 + $105 S&H; C9¼-S (#11045): $1,399 + $85 S&H; C8-SGT (#11026): $1,299 + $75 S&H; C8-S (#11025): $999 + $85 S&H; C8-NGT (#31062): $949 + $85 S&H; C8-N (#31061): $649 + $65 S&H; C6-RGT (#21020): $999 + $95 S&H; C6-R (#21019): $799 + $75 S&H; C6-N (#31056) $399 +$50 S&H; C5-SGT (#11072): $1,099 + $75 S&H; C5-S (#11071): $849 + $65 S&H; C4-R (#21016): $399 + $40 S&H

*Prices shown are U.S. mail order.

CELESTRON®

2835 Columbia Street • Torrance, CA 90503 • Tel: 310.328.9560
www.celestron.com

THE DEEP SKY

Far beyond our solar system, the nearby stars, distant star clusters, and remote galaxies of the constellation Pegasus lurk.

The great square

Pegasus may be the mythological flying horse, but to most backyard observers, it's a large, conspicuous square in the sky. Meteor watchers and deep-sky observers often use the square to find their limiting magnitude — how faint they can see without optical aid. Let your eyes adapt to the dark for thirty minutes or more, and then count the number of stars you see within the triangle formed by Alpha (α) Andromedae and Alpha and Gamma (γ) Pegasi (include the three corner stars).

A count of eight means you can see down to magnitude 6.0, but that number jumps to seventeen if your limiting magnitude rises to 6.5. On exceptionally transparent nights far from any light pollution, your count could exceed thirty, indicating a limiting magnitude of 7.0 or higher. The International Meteor Organization has counts for other areas of the sky.

Cluster: real or fake?

Imagine a river with a row of houses on either side. If we were floating on the river, the houses would appear to stretch out in a broad line in front of and behind us, except for those nearby — they would appear off to the side. That's how it is with open star clusters and the Milky Way; except for the ones nearby, like the Beehive, star clusters all hug the plane of the galaxy.

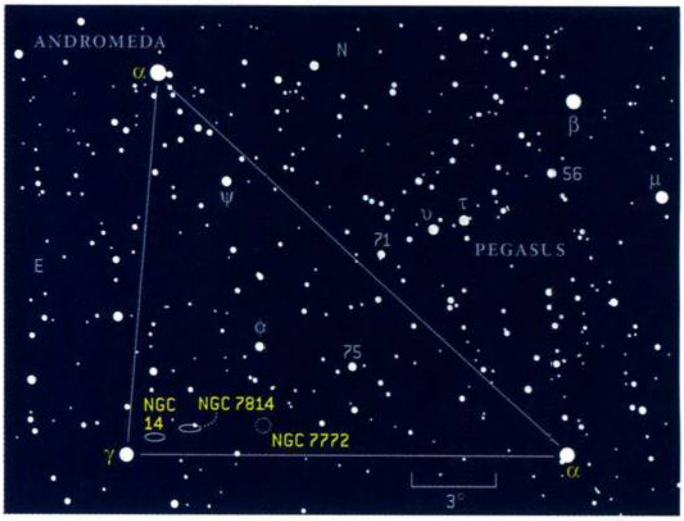
Yet cluster NGC 7772 in Pegasus lies a good distance from the Milky Way but doesn't seem that close to Earth because its brightest stars glow dimly around 12th magnitude. At low power, the cluster appears as a small, freckled cloud. Punch the magnification up to 150x, and you'll see ten stars through an 8-inch scope.

But looks can be deceiving. In 2002, researchers pegged this group of fourteen stars to be about 5,000 light-years away. They also believe it is 1.5 billion years old and in the process of dispersing. Astronomers think our Sun began in a similar small star cluster that dissipated long ago.

Galaxies galore

Much farther into the depths of space are the galaxies, each made up of billions of stars swirling slowly around a common center of gravity. If a bright comet had traversed this area of sky while Charles Messier was cataloging deep-sky fuzzies, he probably would have found NGC 7814. At magnitude 10.6, this edge-on spiral galaxy is only a half magnitude fainter than the toughest Messier objects.

SPIRAL GALAXY NGC 7814 lies in Pegasus, where it glows at 11th magnitude and appears edge-on from our point of view. PRESTON SCOTT JUSTIS



NGC 7814 lies 2.6° west-northwest of Gamma Pegasi, the anchor star for locating Comet C/2002 T7 (LINEAR). Easily visible through a 10-inch scope at low power, the galaxy appears noticeably elongated. A couple decades ago, common, but incorrect, wisdom dictated observers should use low power to view deep-sky objects. At low power, the core of NGC 7814 appears brighter, but not "stellar" like the cores of many galaxies. But pushing the power to 250x or more usually reveals the low contrast dust lane splitting the galactic bulge.

Halfway between NGC 7814 and Gamma Peg lies the fainter galaxy NGC 14. At magnitude 12.1, this round fuzz should be visible through an 8-inch scope, but you'll probably need 125x or more to coax it out of the background sky. These galaxies are best seen when the Moon's out of the evening sky, between February 10 and 22.

Martin Ratcliffe *is former president of the International Planetarium Society.* **Alister Ling** *is a meteorologist for Environment Canada.*

THE PLANETS

The four brightest planets parade across the sky on these chilly winter evenings, providing wonderful views for both naked-eye and telescopic observers.

The forecast for planet viewing in February looks good: Venus, Mars, Jupiter, and Saturn are all visible during the evening hours. Venus is the brilliant "evening star" that appears in the west at dusk. As the sky darkens, you'll find Mars high in the southwest, looking like a bright orange star well above Venus. At the same time, Saturn stands high in the southeast among the stars of Gemini. Jupiter rises a couple hours after the Sun sets and clears the murky horizon by mid-evening; the solar system's largest planet lies among the stars of Leo.

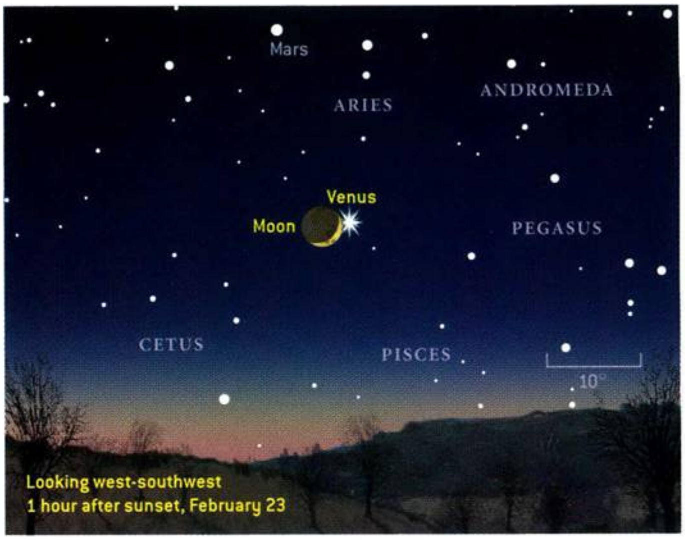
As the sky darkens after sunset, **Venus** shines brilliantly in the west-southwest. Easily the brightest object in the sky (except when the Moon's out), Venus proves unmistakable. At magnitude –4.1, the planet easily overpowers the faint background stars of Pisces the Fish. To the naked eye, the most spectacular view occurs on February 23, when Venus lies just 3° to the right of a slender crescent Moon. By the following night, the Moon has climbed some 12° above Venus.

The distance between Earth and Venus shrinks throughout February, prompting changes in Venus's appearance that can be followed easily through a small telescope. The planet's apparent diameter grows 20 percent during February, from 15" on the 1st to 18" on the 29th. With increasing size comes a drop in the fraction of the disk that appears illuminated. Although the phase remains gibbous, it wanes from 75 percent lit to 65 percent lit.

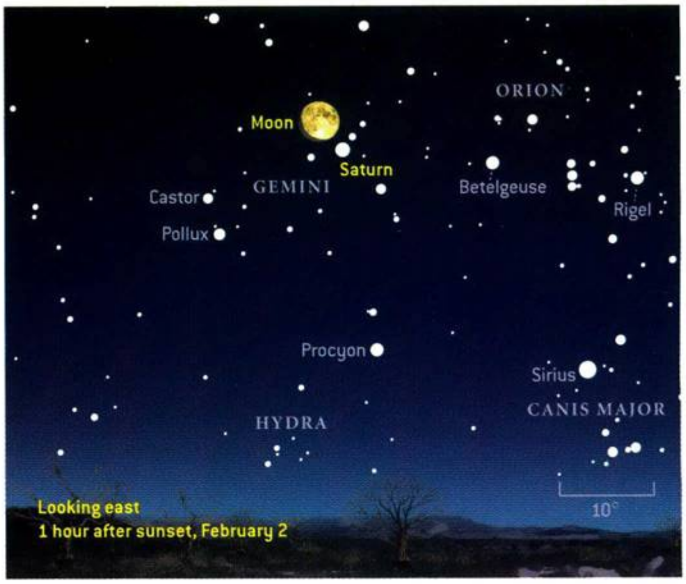
If you think Venus looks great now, just wait a bit. For observers in the Northern Hemisphere, the planet has embarked on its best evening apparition in a decade. Over the next couple months, it will climb higher and shine brighter while its telescopic appearance changes radically.

In marked contrast, **Mars** continues to fade in brightness and shrink in the eyepiece as its distance from Earth grows. The Red Planet dims 30 percent during February, from magnitude 0.7 to 1.1, while its apparent diameter dwindles from 6.7" to 5.7". The tiny disk requires a large telescope (12 inches in aperture or larger) if you want to see any surface features. (However, the planet's 90-percent-lit phase still will be noticeable through smaller scopes.)

Tracking Mars's motion against the starry background should be more interesting to observers now. The planet traverses most of Aries the Ram during February, well south of the constellation's brightest stars. You can see the crescent Moon glide just 0.9° south of Mars on February 25. The following evening, the seven-day-old Moon stands 5° below the Pleiades star cluster with Mars 11° below the Moon. By February 29, Mars lies 13° below the Pleiades.



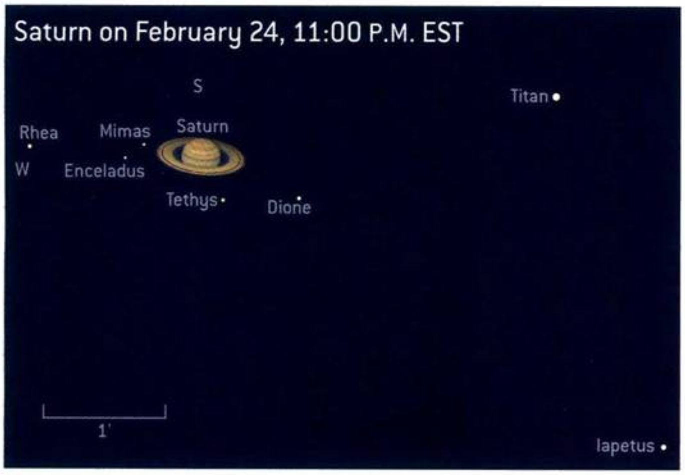
Looking west-southwest
1 hour after sunset, February 23



Looking east
1 hour after sunset, February 2

Because the orbital speed of Mars is not that much slower than Earth's, the Red Planet will linger in the evening sky through early summer. While the outer planets like Jupiter and Saturn sink fairly quickly into the solar glare, Mars treks eastward relative to the stars fast enough to stay ahead of the twilight glow. During May, it will catch up with Saturn, resulting in a fine conjunction.

Saturn stands high in the southeast as twilight ends. It's a spectacular telescopic object lying near the western end of Gemini. In mid-February,


Saturn on February 24, 11:00 P.M. EST

Saturn shines at magnitude –0.2 and its disk spans 20". Adding the rings brings the system up to 45", about the same apparent size as Jupiter. With the southern face of the rings tipped 26° to our line of sight, any telescope will provide a stunning view.

On both February 2 and 29, Saturn lies about 5° south of a gibbous Moon. The planet spends the entire month near Mu (μ) and Eta (η) Geminorum, the two 3rd-magnitude stars at the northwestern end of Gemini. Saturn nudges nearer to Mu as February progresses. By the 29th, the planet stands 1° shy of the star, the closest they will get. In the first week of March, Saturn ends its westward motion and begins to move back across Gemini.

You'll find the best views of Saturn in mid-evening, after twilight has ended and Saturn has climbed high in the sky. (Saturn passes nearly overhead around 10 P.M. in early February and 8 P.M. late in the month.) Although most beginners see nothing more than a bland yellow disk, experienced observers using modest-size telescopes typically see the bright Equatorial Zone sandwiched between the darker North and South Equatorial Belts. Even the smallest scope will show detail in the rings. Look for the black Cassini Division separating the outer A ring from the brighter B ring. On nights with steady seeing, you may glimpse the narrow Encke Gap near the outer edge of the A ring and the gauzy C ring closest to Saturn.

Saturn's brighter moons are always on display to those with a telescope. Titan, glowing at magnitude 8.3, is the most obvious. Moons closer to Saturn, like Tethys, Dione, and Rhea, glow at 10th magnitude and can be glimpsed through a 6-inch scope. Enceladus poses a greater challenge at magnitude 11.7.

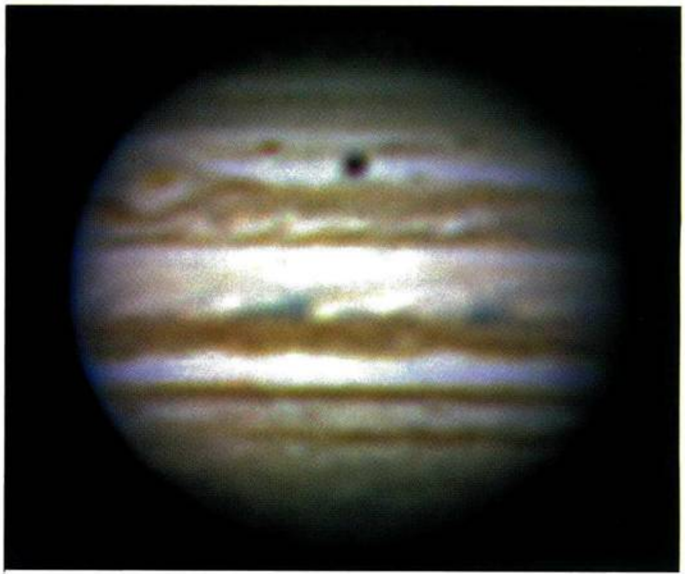
Farther from Saturn lies Iapetus, the moon that dims and brightens as it orbits the planet. It appears brightest on the western side of Saturn, when its more reflective hemisphere faces us. Iapetus then glows at magnitude 10.1. As Iapetus moves east of Saturn, it fades by 80 percent to magnitude 11.9. On February 1, Iapetus lies 9' east of Saturn and glows dimly. Watch the moon brighten slowly as it moves westward relative to Saturn throughout this month and next.

As Venus sinks low in the western sky, **Jupiter** rises in the east, where the brilliant planet lies near the hindquarters of Leo the Lion. It climbs 10° above the horizon by 9 P.M. in early February and by 7 P.M. toward month's end.

Jupiter shines at magnitude –2.5 and appears stunning. Through a telescope, its large apparent size provides spectacular views of its ever-present cloud belts. Jupiter's fast rotational period, less than ten hours long, offers different views of the planet each hour. You can watch features like the Great Red Spot cross the disk as the giant planet turns. Timing features as they cross the central meridian (an imaginary vertical line joining both poles and splitting the planet's visible hemisphere in two) will allow you to calculate the longitude of those features using an astronomical almanac.

The four bright moons of Jupiter offer additional attractions as they orbit the planet. Io is the speedy one, orbiting in less than two days; its position relative to the three other moons changes in a matter of hours. Europa, Ganymede, and Callisto move more sedately due to each moon's increasing distance from Jupiter.

That pretty much covers the visible planets this month. Both **Uranus** and **Neptune** reach solar conjunction (on February 21 and 2, respectively) and are lost in the Sun's glare. You might catch a quick glimpse of **Mercury** in early February; for an observer at 40° north latitude, it lies 5° high in the southeast half an hour before sunrise. A telescope will show a gibbous disk some 5.5" across shining at magnitude –0.2.


JUPITER SHINES BRIGHTLY this month as it approaches opposition. It rises during mid-evening and remains visible all night. SUBARU TELESCOPE/NAOJ

METEORS AND MOONS

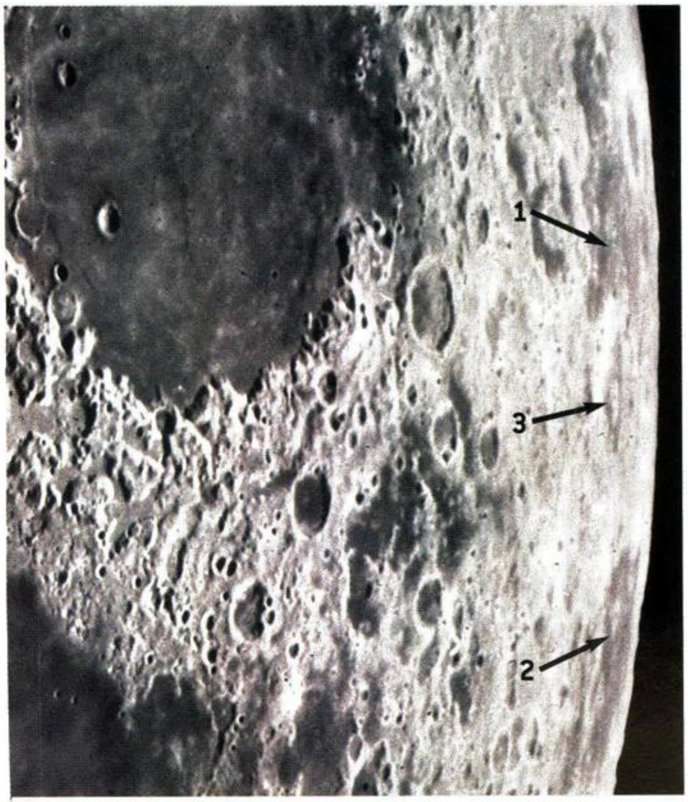
Callisto continues to play tag with the disk of Jupiter, while a favorable lunar libration brings seldom seen features on the Moon's eastern limb into view.

No significant meteor shower takes place during February. The nightly rate of sporadic meteors — those that appear at random and are not associated with a shower — typically averages seven per hour. A "fireball" will appear rarely, lighting the sky with a brief but brilliant flash; fireballs are magnitude –3 or brighter, outshining Jupiter.

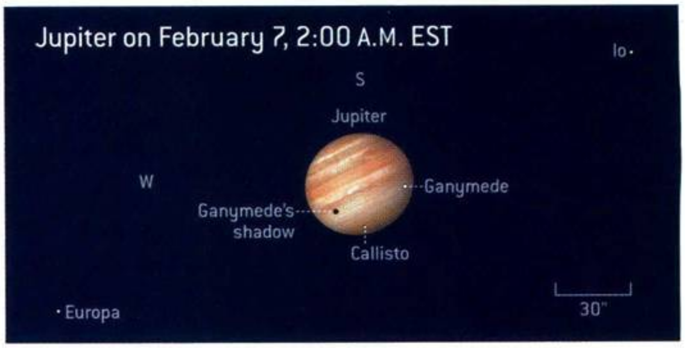
Probe the eastern limb

Here's a lunar challenge for you. Three features — Mare Marginis, Mare Smythii, and Neper crater — sit on the extreme eastern edge of the Moon, beyond Mare Crisium. The region often turns away from Earth, and lighting changes also complicate things for the observer. Try spotting the region shortly after the New Moon on February 20, when that part of the Moon tips favorably in our direction. Only when the lunar libration is just right can these features be viewed easily.

Neper crater measures 85 miles across and has a prominent central peak and a flat crater floor filled with lava. It lies midway between Mare Marginis (to the north) and Mare Smythii (to the south). Beyond Neper lies a smaller crater, Jansky, that's even more difficult to view. The two maria often sit right on the limb, with Mare Marginis somewhat easier to see. Also look for the dark, fingerlike extensions that seem to reach from Mare Crisium toward Mare Marginis.



THE EASTERN EDGE of the Moon shows many interesting features under a favorable libration, including Mare Marginis (1), Mare Smythii (2), and the crater Neper (3). FROM *THE CONSOLIDATED LUNAR ATLAS* (LPL/UA)



/// FEBRUARY CALLISTO EVENTS

	{ UT }	{ EST }	{ Event }
6th	22h59m	17:59	Sh.I.
		21:41	Sh.E.*
7th	02h41m		Sh.E.*
	05h07m	0:07	Tr.I.
	07h46m	2:46	Tr.E.
15th	07h31m	2:31	Ec.D.
	11h13m	6:13	Ec.R.
	12h04m	7:04	Oc.D.
	14h44m	9:44	Oc.R.
23rd	16h58m	11:58	Sh.I.
	19h30m	14:30	Tr.I.
	20h34m	15:34	Sh.E.
	22h13m	17:13	Tr.E.

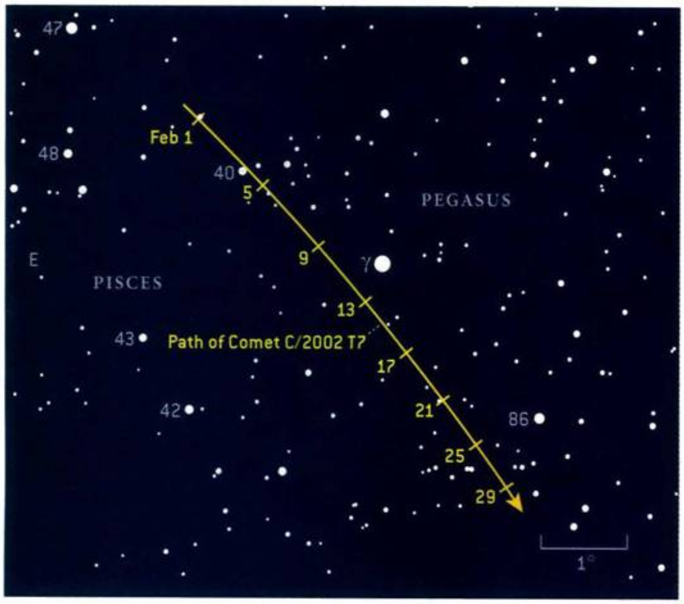
*Events that occur on either side of midnight are shown twice.

Jupiter's satellites

The rare series of occultations, eclipses, and transits involving the outer Galilean moon, Callisto, continue throughout February. During each twelve-year orbit of Jupiter around the Sun, only two series of these Callisto events take place. The current one began in late 2001 and continues until September 2004. During this time, sixty-six eclipses occur. February's events listed in the table above are given in 24-hour format in both Universal Time and Eastern Standard Time. Those that occur on either side of midnight are listed twice because the date changes for observers depending on whether they live in Europe or North America. Tr = transit; I = ingress; E = egress; Oc = occultation; Sh = shadow transit; Ec = eclipse; D = disappearance; R = reappearance. The events are worth viewing due to their relative rarity. Not all the events can be seen from any one observing location.

COMETS AND ASTEROIDS

Comet C/2002 T7 (LINEAR) continues to brighten but will disappear in early March. Meanwhile, asteroid number one cruises through the sky not far from Saturn.



A binocular snowball

If you're a regular reader of this column, you already know that two naked-eye comets will provide an observing feast this coming spring. Comet C/2001 Q4 (NEAT) will vault tail-first into the evening sky in May, while the appetizer, C/2002 T7 (LINEAR), will help us hone our observing skills.

Comet C/2002 T7 makes a fine binocular target this month, appearing as a 7th-magnitude white fuzzball. Although 7th magnitude may not sound thrilling compared with the comet's predicted peak near 1st magnitude, comet observers know they're lucky if they can get even one comet a year bright enough to see with binoculars.

C/2002 T7 is perfectly placed in the evening sky during the first half of February, more than 30° above the western horizon when it's fully dark. It's a snap to find, too, because it lies near the 3rd-magnitude star Gamma (γ) Pegasi. Just point your binoculars or finder scope at Gamma, the star marking the southeastern corner of the Great Square of Pegasus, and you'll see the comet. Because the square now tilts on its end as seen from the Northern Hemisphere, Gamma appears to be the left corner.

In case the season's weather is poor, it's probably best to look for the comet whenever it's clear, even if the Moon is in the sky. The best conditions occur a couple nights after Full Moon on February 6, when the Moon's annoying glare will have left the evening sky. Moonlight returns to the stage after the 22nd.

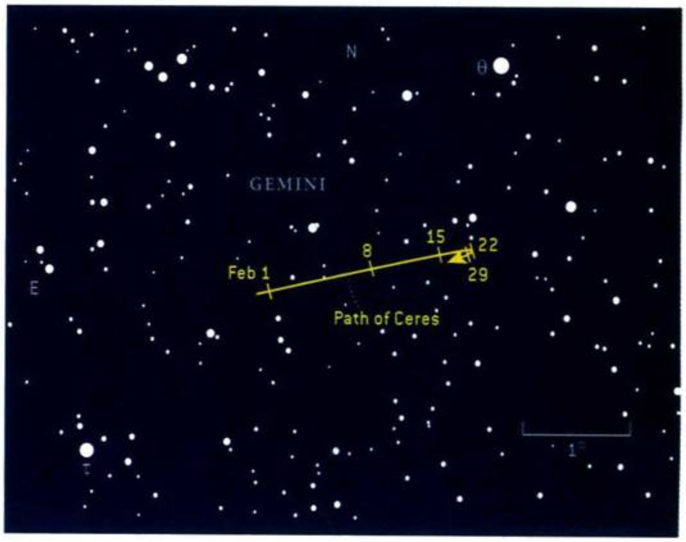
The comet's tail, just visible through binoculars, will be much more evident when viewed through a telescope. C/2002 T7 already glows as bright as the Messier galaxy M81, so you should see plenty of detail from a dark site. If the tail seems to be going the wrong way, you may have forgotten that your scope inverts the image of a celestial object. It's always fun to see how far you can follow a comet's tail. Use all your observing skills, from employing a dark hood to eliminate stray light to gently rocking your scope to detect the fainter parts of the comet's tail.

Pump up the power, too. Who knows what you'll be able to see as you look toward the comet's core? Will there be curved jets like there were on Comet Hale-Bopp or a greenish glow and tail shadow like on Comet Hyakutake?

A small-scope asteroid

Asteroid 1 Ceres is by far the largest object in the asteroid belt, yet it's not the brightest. At 580 miles across, it's almost double the size of either Vesta or Pallas, the runners-up. The difference lies in its reflectivity — almost four times less than that of Vesta.

From a suburban backyard, you certainly will be able to follow Ceres's movement using binoculars. Glowing at about magnitude 7.5 just a couple degrees south and east of 4th-magnitude Theta (θ) Geminorum, Ceres should be easy to pick out from the dearth of surrounding stars. The asteroid will confirm its solar system roots by moving relative to the background; the nightly shift will be obvious through a small scope, but it may take three or four nights for those using binoculars to detect any change. ■



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CGE, metal tripod, 2-axis go-to	3000^{00}
Losmandy GM8, metal tripod, 2-axis drive	1449^{00}
GM8GT, metal tripod, Gemini go-to	2449^{00}
GM11, metal tripod, 2-axis drive	2079^{00}
GM11GT, metal tripod, Gemini go-to	3195^{00}
HGM Titan, metal tripod, 2-axis drive	5995^{00}
Meade Starfinder, metal pier, 1-axis drive	1995^{00}
LXD650, metal tripod, #1697 go-to	2595^{00}
LXD750, metal tripod, #1697 go-to	3595^{00}
Questar 7" Fork, no tripod, 1-axis drive	6495^{00}
Software Bisque Paramount ME, *no pier or tripod, 2-axis go-to*	*10,000^{00}*
Takahashi P2Z, wood tripod, 1-axis drive	2219^{00}
EM-2S, wood tripod, 1-axis drive	2219^{00}
EM-10, wood tripod, 2-axis drive	2789^{00}
EM-10GT, wood tripod, Temma go-to	3589^{00}
EM-200, wood tripod, 2-axis drive	4449^{00}
EM-200GT, wood tripod, Temma go-to	5299^{00}
NJP/T, wood tripod, 2-axis drive	6049^{00}
NJP/TGT, wood tripod, Temma go-to	6949^{00}
NJP/P, metal pier, 2-axis drive	6049^{00}
NJP/PGT, metal pier, Temma go-to	6949^{00}
Vixen GP, metal tripod,drive opt.	800^{00}
GPW, wood tripod,drive opt.	980^{00}
GPDX, metal tripod,drive opt.	1220^{00}
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\$1695
Meade 8" LX90

The **Meade LX90** lets you enjoy go-to astronomy for not a lot of money. The 8" LX90 with standard optical coatings is only \$1695. UHTC (Ultra High Transmission Coatings) optics give you up to 20% brighter images for only \$175 additional. The LX90 has an adjustable height tripod, LPI (electronic camera), 26mm Super Plössl eyepiece, Autostar computer control, and an 8 x 50mm finder.

We usually have the LX90 in stock at all times (both standard and UHTC versions), so you can probably get *your* LX90 with little or no delay. If Meade is shipping the LX90 *(or any Meade telescope)* for a dealer to keep in stock, the chances are very good we *have* it in stock.

Vixen scopes and mounts are in stock.

Not only telescopes and mounts, but the complete range of Vixen accessories as well – Lanthanum long eye relief and wide angle long eye relief eyepieces, camera adapters, filters, focal reducers, Barlows, and more. Whether it's a telescope, mount, or accessory, if it's from Vixen, chances are good we have it in stock.

Here's a *partial* list of the complete Vixen scopes we had in stock as this was written:

V102MG, 4" achromat, GP mount	**\$1350^{00}**
VE80SG, 3.1" ED apo, GP mount	**1655^{00}**
VE102SG, 4" ED apo, GP mount	**2200^{00}**
VF80SG, 3.1" fluorite apo, GP mount	**2280^{00}**
VF102SG, 4" fluorite apo, GP mount	**2900^{00}**
VR200G, 8" f/4 reflector, GP mount	**1700^{00}**

If you want a Vixen optical tube only, we stock their achromats, fluorite apochromatics, ED apos, and dual ED apo refractors. We also stock Vixen's reflector and catadioptric optical tubes, and the well-known and highly-rated Great Polaris and Great Polaris DX German equatorial mounts to use with your own optics.

Check our website for a complete listing and current inventory of the Vixen products we keep in stock, or you can call us toll-free at (800) 422-7876 to see for yourself.

Vixen

\$2200
Vixen VE102SG 4" f/9 ED apo refractor (w/optional drive)

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We'll sell you the *right* telescope.

This month's hot new product . . .
the Meade Autostar Suite and Lunar Planetary Imager!

\$149

This software/camera package integrates your telescope with your PC. Its planetarium software has 19,000,000 stars and objects. Use it for point and click control of your go-to scope's motion or as a stand-alone observing planner when nights are cloudy. Its Lunar Planetary Imager, shown, is a powerful and simple-to-use full color electronic camera. It also works as an autoguider for deep space photography. The software works with all Meade telescopes using an Autostar II or #497 hand control (recent LX200GPS, ETX-90/105/125 Maksutovs, LX90, and LXD-55 scopes with Autostar).

A \$450 bonus with SBIG CCD cameras.

Buy any of the SBIG CCD cameras listed below from our stock and we'll give you \$450 worth of useful extras for free! You'll get a \$399 **Maxim DL/CCD** software package – the only telescope, camera, and image processing software you'll ever need. You'll also get a copy of Ron Wodaski's \$50 book **The New CCD Astronomy**. It's widely regarded to be the best CCD book ever. You'll find full details on both the software and CCD book elsewhere in this ad. This offer good only while the quantities shown below last.

Here are the SBIG CCD cameras that will get you the \$450 bonus:

SBIG ST-2000XM, quantity available 9	**\$3495^{00}**
SBIG ST-9XE, quantity available 12	**3695^{00}**
SBIG ST-10XME, quantity available 6	**6995^{00}**

Sell your used telescopes and accessories quickly *for free* by using the no-charge classified ads at

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The best CCD book . . .

\$49^{95}

Before you spend \$3000 on a CCD camera (or even \$249), spend \$49.95 on this informative book.

The New CCD Astronomy by Ron Wodaski is the best and most complete imaging reference available for CCD photographers of all skill levels. It includes everything you need to know to become proficient at CCD imaging, plus a free subscription to on-line updates and reference materials.

Our *38* light pollution filters make bright skies dark.

If city lights wash out your view of the skies, get rid of the pollution with one of the 38 different light pollution reduction filters we stock.

We have two **Celestron** broadband filters. One is designed for 1.25" eyepieces; one for Schmidt-Cassegrain (SCT) rear cells.

We have 13 **Lumicon** Deep Sky broadband, UHC narrowband, and H-Beta and Oxygen III line band filters for use in 1.25" and 2" eyepieces, as well as on SCT rear cells.

We have six **Meade** broadband, narrowband, and Oxygen III filters in 1.25" eyepiece and SCT rear cell versions.

We have four **Sirius** contrast enhancement and nebula filters for 1.25" and 2" eyepieces, plus a unique 1.25" *variable* nebula filter.

We have four **TeleVue** Bandmate NebuStar UHC-type narrowband and Oxygen III filters in both 1.25" and 2" eyepiece versions.

We have eight **Thousand Oaks** broadband, narrowband, Oxygen III, and H-Beta filters in both 1.25" and 2" eyepiece versions.

Some dealers carry a few filters. We carry 38. We have one that's right for you.

There's nothing mysterious about this Sphinx!

The **Vixen Sphinx** telescopes and mounts take the mystery out of go-to astronomy. You don't have to know Messier, NGC, or IC numbers to have your scope find deep sky objects.

Vixen Star Book hand control showing star chart display

Simply move the crosshair cursor over the object displayed on the Star Book hand control's 4096-color LCD star chart screen. Push a button and the Sphinx mount moves to that object. Zoom-In/Out buttons for the star chart display also control the motor speed. As you zoom in on an object displayed on the screen, the motor speed automatically slows for more accurate control. Zoom out and the motor speed increases to cover large distances quickly.

The Star Book control's 4MB flash ROM memory can be updated from the Internet to keep you current with the heavens. And the easy-to-use Star Book controller can be used as a stand-alone star atlas to learn the skies anywhere, anytime.

FL80SWT-SXW
3.1" f/8 fluorite apo Vixen refractor on Sphinx go-to mount
\$3910

The Sphinx go-to mount with Star Book controller is available separately for use with your own optics. It is also available in ultra-premium Vixen telescope packages that range from an 3.1" f/5 refractor on a supremely portable tabletop go-to mount to big 8" reflectors and catadioptrics on full length field tripods.

You'll find full Vixen Sphinx details and prices on our **www.astronomics.com** website.

Everyone can afford CCD when cameras start at \$249!

SAC7B cooled 24-bit color
\$499

Low cost **SAC Imaging** CCD cameras finally make serious CCD imaging possible at sensible prices. Even the owners of small telescopes (such as the Meade ETX-90) can do serious CCD imaging with a very affordable SAC camera.

Whether it's short exposure lunar and planetary shots, long exposure deep space photos, black and white imaging, single-pass full color, tri-color with a filter wheel, or auto-guiding – there's an inexpensive SAC CCD camera to do it. You'll find full details and pricing on all of them on our website at **www.astronomics.com**.

Right angle finders available from stock from \$89.

We stock **Antares** 8 x 50mm and 11 x 80mm right angle finders from \$89 to \$217^{50}. Choose from gloss white, Celestron black, or Meade blue in your choice of a mirror-image or erect right-reading version that shows you the sky the way it appears on star charts. Optional mounting rings are also available.

Antares 11 x 80mm
\$210

Get a go-to *now.* Celestron ships from stock.

Celestron Advanced Series scopes put multicoated optics on an easy-to-use go-to mount. From a 5" SCT (with optics so good that NASA flies them on the Space Shuttle) to a 10" reflector, there's a Celestron go-to that's right for you and your budget. You can even get state-of-the-art Starbright XLT multicoatings as an option on the bigger SCTs. Scopes include:

an 8" Newtonian reflector	**\$949^{00}**
a 6" achromatic refractor	**999^{00}**
a 5" Schmidt-Cassegrain	**1099^{00}**
a 10" Newtonian reflector	**1149^{00}**
an 8" Schmidt-Cassegrain	**1299^{00}**
an 8" SCT with XLT coatings	**1424^{00}**
a 9¼" Schmidt-Cassegrain	**1699^{00}**
and a 9¼" SCT with XLT coatings	**1874^{00}**

Each has a heavy duty adjustable height tripod with rigid 2" diameter steel legs instead of the lighter aluminum legs used in other scopes. Their go-to computers have a database of 45,000+ stars and objects they can find for you. High speed dual-axis DC servo motor drives are standard. The list of features goes on and on – at prices starting as low as \$949. These Celestrons ship from our stock. There's no waiting for a manufacturer to dropship your scope.

Celestron C 8 S-GT 8" go-to
\$1299
(\$1424 with optional XLT coatings)

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A Celestron rechargeable battery for only \$59^{95}!

It's our best-selling accessory ever. We order 200 at a time and still have trouble keeping them in stock! The **Power Tank** 7 amp-hour 12V DC rechargeable battery runs your scope all night long. It has two cigarette lighter outputs; separate 3, 6, and 9V DC accessory outputs; emergency spotlight; recharger; shoulder strap; and more. It's only \$59^{95}. Why pay more for a battery that does less?

Maxim CCD software gives you maximum results.

\$299

Maxim DL software for Windows lets you take full control of your CCD image processing. Forget intimidating manuals and complex commands – dozens of powerful image processing capabilities are now only a mouse click away. Use the latest imaging techniques including DDP, LRGB, LCMY, mosaics, and much more! This \$299 software package is widely considered to be the gold standard of CCD image processing software.

Maxim DL/CCD adds integrated control of all CCD camera, autoguider, telescope, and electric focuser functions to the superb Maxim DL image processing program. It controls Apogee, Celestron, Finger Lakes, Meade, SBIG and Starlight Xpress CCD cameras. It even lets you continue working with images during an exposure. This single \$399 package may be the only telescope, camera, and image processing software you'll ever need.

Do Celestron CGE go-to scopes have the perfect mount for astrophotography?

Astrophotography with a fork-mounted go-to Schmidt-Cassegrain has its drawbacks. You can't use its altazimuth mount to take long exposure photos without adding a costly equatorial wedge or field derotator. Use a wedge and you can't image near the celestial pole or the southern horizon, and tube vibrations can become a problem. Use a field derotator and you lose periodic error correction and can't image near the zenith. In larger apertures, fork-mount scopes usually require two people to set up.

Celestron CGE German equatorial go-to scopes solve these problems. Even the big 14" CGE1400 can be set up by only one person. The CGE mount can reach all parts of the sky, without adding a costly wedge or field derotator. And German mounts are known for being virtually vibration-free.

\$4150
Celestron CGE1100

Celestron CGE scopes with Starbright multicoatings are available as complete go-to systems in 8" to 14" apertures, or as a go-to mount only. You can add a GPS system for only \$199. You can even add state-of-the-art Starbright XLT coatings for Celestron's brightest images ever.

Only \$999 for a 5" GPS-ready Celestron SCT!

The **Celestron NexStar 5i** is the *only* 5" telescope to have a fully automatic GPS go-to computer available as an option. No other 5" scope has GPS! The NexStar 5i has a computer hand control with a 45,000+ star and object database, tripod, finder, eyepiece – everything you need to start observing immediately!

Multicoated optics are *standard equipment* with the NexStar 5i, not an option as with other scopes. NASA uses Celestron 5" multicoated optics on the Space Shuttle. Don't your eyes deserve the same premium image quality?

\$999
the Nexstar 5i is shown with optional photography accessories

NexStar 5i

CELESTRON

The Celestron NexStar 8i GPS-ready 8" go-to SCT costs only \$1299!

The \$1299 **Celestron NexStar 8i** costs far less than other comparably-equipped 8" go-to scopes. You can start observing as soon as you take it out of the box. Its computer has a library of 45,000+ stars and objects it can find for you. It has a tripod, red dot finder, and eyepiece. Starbright multicoatings are standard, not an optional extra. If you want GPS (an unavailable option on other scopes), it's only \$199. The NexStar 8i is enough scope to keep you observing for the rest of your life, at a price that leaves other scopes behind.

NexStar 8i
\$1299
the Nexstar 8i is shown with all standard accessories

This \$199^{95} box holds the entire Universe!

Desktop Universe is a full-color photographic star atlas combined with a powerful desktop planetarium program. It shows you stars to magnitude 14, the visual limiting magnitude of an 8" telescope. It shows star clusters, nebulas, and galaxies as your eye sees them through your scope, not as abstract symbols the way other planetarium programs show them. *Sky & Telescope* named it a Hot New Product and called it "visually stunning . . . It just might be the biggest advance in portraying the night sky since the paintings on the ceilings of Egyptian tombs." Of course it also controls your go-to telescope, prints sky charts for use at your scope, and does all the other useful things a great planetarium program should.

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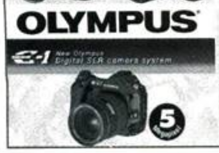

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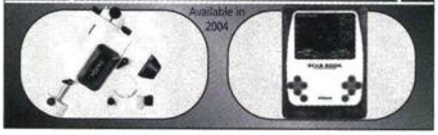

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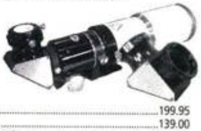

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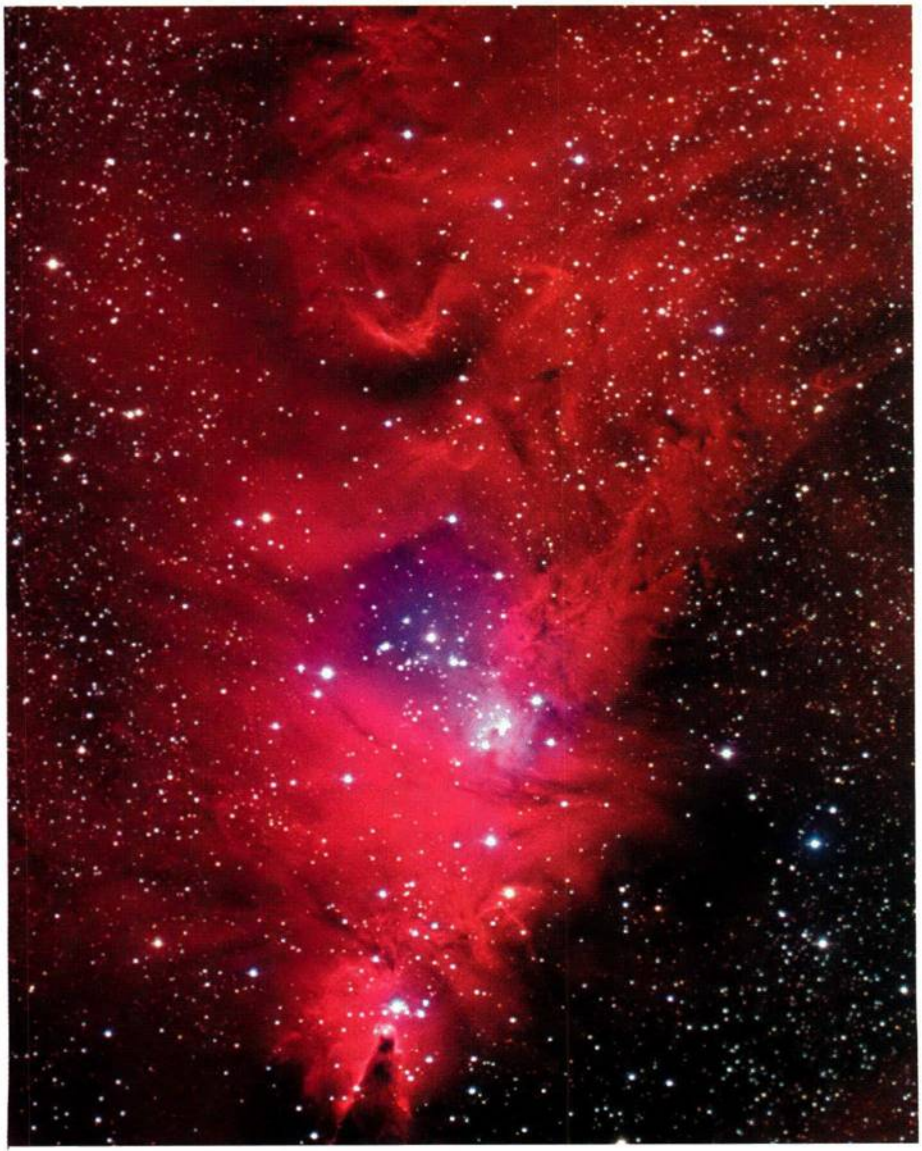
ASK ASTRO

Are astrophotographic colors real?; Axial tilt and climate; Twinkle, twinkle

ARE ASTROPHOTOGRAPHIC COLORS REAL?

I thoroughly enjoy the colorful pictures in the magazine, but I have always wondered if the colors are real or if they result from some sort of photo-processing? Do we really see all those reds, blues, and greens looking through a telescope? — **MARK MISSEN,** TORONTO, ONTARIO, CANADA



THE CONE NEBULA'S vivid colors are real — but film and CCDs have a big advantage over the eye when it comes to perceiving color: They can accumulate light over a long exposure. DANIEL PHILLIPS

The answer comes in two parts: Yes, the colors are real, and no, we usually don't see them. Objects in space show us their true colors in several ways. For example, the planets of the solar system shine by reflecting sunlight. The creamy yellows and browns of Saturn, the blue of Neptune's atmosphere, and the red rocks and soil on Mars appear that way because those are the colors each reflects most strongly.

Deeper in space, the most colorful objects are nebulae. A small percentage of these are reflection nebulae. As the name implies, these reflect light from nearby stars. Because they are made of gas and dust, these objects don't just reflect the light, they also scatter it, which makes them appear bluish. The same thing happens on Earth: Sunlight scattered by our atmosphere colors the cloudless sky blue.

Most visible nebulae are emission nebulae (and, yes, there are combination emission/reflection nebulae). An emission nebula shines because hot stars within the cloud excite the atoms of gas (raising them to a higher energy level). The gas then re-emits the energy as colored light.

So nebulae come in a variety of beautiful colors. But why don't we see these vivid colors through telescopes? The answer is that most objects aren't bright enough to trigger the color receptors in our eyes.

Human vision comprises two types. Photopic vision is what we employ mainly in the daytime when looking at objects flooded with light. Sometimes called just "color vision," it involves the receptors in the eye known as cones. Scotopic vision operates under low illumination and involves the receptors called rods. For photopic vision to be triggered, the object must be reasonably bright — or a telescope must be large enough to show it as bright.

Take star color, for example. Ninety-nine percent of all stars appear white. Why? It's not because all those stars are white. It's because they're not bright enough to trigger the cones in our eyes. Several bright stars do appear colored to the naked eye, however — orange Arcturus, blue Rigel, yellow Capella, red Betelgeuse, and others. More stars look colored through telescopes, which collect much more light than our eyes. The bigger the scope, the more colored stars it will show. Find Albireo, the head of Cygnus the Swan. By eye, this star appears white. But through even a small telescope, Albireo resolves into a pair of stars, one sapphire blue and the other golden yellow.

In addition, the detectors used by astrophotographers have a big advantage over eyes. A film or CCD camera can collect light for seconds, minutes — even hours. Your eye is limited to a 1/30-second exposure. That is, the eye's shutter opens and closes 30 times a second. This limitation allows only so much light into the eye at any one time, and it guarantees that cameras will record much greater detail and color. So enjoy the pictures!
— **MICHAEL E. BAKICH,** ASSOCIATE EDITOR

EARTH'S MASSIVE MOON stabilizes the tilt of our planet's rotation axis, helping to constrain climatic changes. Some biologists theorize that such stability was critical for the emergence of life. NASA/JPL

AXIAL TILT AND CLIMATE

Is the 23.5° tilt of Earth's axis fixed? Does the tilt change? If so, how does this affect the climate — for instance, do polar regions get a more direct hit of the Sun's energy?
— **JOE PAZOUREK,** MIDDLE RIVER, MARYLAND

Basic earth science teaches us that the tilt of Earth's rotation axis with respect to the Sun — which is properly known as the obliquity of the ecliptic — has a constant value close to 23.5°. But "constant" isn't really constant when viewed on a timescale far longer than a human lifetime.

In fact, Earth's obliquity varies as a result of small gravitational perturbations from the Sun and other planets. Fortunately, our massive Moon acts to keep this variation confined to a very small range: a little over 2°. The extreme values are about 22.1° and 24.5° during a cycle of about 41,000 years. Currently, the obliquity is decreasing by just under 0.4 arcseconds per year. Planetary scientists calculate that an increase or decrease of 1° in obliquity results in an increase or decrease of about 1 percent of the total solar heating in the hemisphere pointed toward the Sun at a given solstice.

A far larger effect on the climate seems to be linked to long-term variations in the eccentricity of Earth's orbit. This number is a ratio of the major axis of Earth's elliptical orbit to its minor axis, which is currently about 0.016. It can vary from 0.0005 (very nearly circular) to 0.0607 over a timescale of about 100,000 years. As eccentricity increases, the extreme distances of Earth from the Sun become more pronounced, with Earth being closer to the Sun at perihelion and more distant at aphelion. This changes the annual variations in temperature extremes at the solstices, and thus, it has a much greater effect on long-term climate changes.

It is interesting to compare these figures with similar ones for Mars. The Red Planet orbits much closer to Jupiter, which exercises significant perturbations on the planet. Mars's obliquity varies between about 15° and 35°, and its eccentricity (currently 0.093) varies between near-circular and 0.14. These two factors combine to give Mars great climatic variation — from an airless world whose atmosphere is frozen out onto the surface, to one of extreme seasons with violent atmospheric processes in constant turmoil as the seasons change.
— **GEOFF CHESTER,** U.S. NAVAL OBSERVATORY

TWINKLE, TWINKLE

On a trip to the Grand Canyon, a companion and I saw what we took to be a police car parked on the rim with a flashing red, blue, and white light. Then we saw that it was a bright star rising over the canyon's edge. My friend identified it as Arcturus. What's going on with this star that it produces such a brilliant light show?
— **DAVID J. PIPPIN,** KANSAS CITY, MISSOURI

Actually, any star will show the same effect you saw, but it becomes very noticeable with bright stars such as Arcturus. Just before it reaches your eye, the light from the star passes through a highly distorting layer of Earth's atmosphere, and this causes the starlight to flicker and change color from moment to moment.

The distortion occurs because sunlight falls on the ground during the day and heats it. By night, the ground loses the heat by warming the layer of air above it. At both times, the warmth lowers the air's density, changing how it bends light that passes through it. Moreover, the changes occur from one second to the next as cells of warm air burble up and disperse — hence the flashing you saw. Dimmer stars usually don't shine brightly enough for the naked eye to see flashes, but a look through binoculars or a telescope shows the effect clearly. — **ROBERT BURNHAM,** SENIOR EDITOR

THE GLORIOUS CONSTELLATIONS
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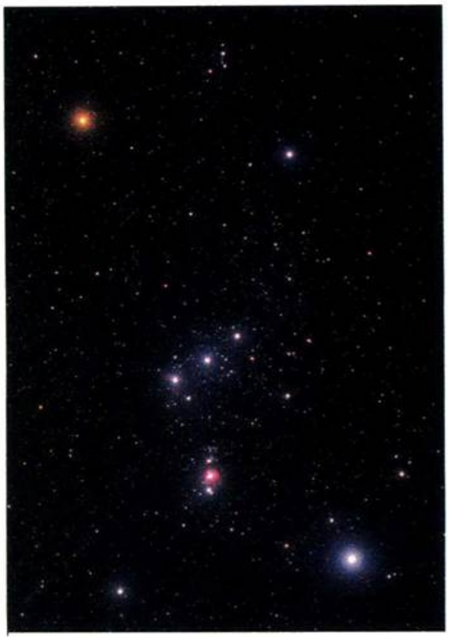
Orion the Hunter

Famous for bold stars and strong, linear features, the Hunter trims his warrior attire with some of the most gorgeous nebulae in the sky. /// BY TOM POLAKIS

No constellation dominates the winter sky like Orion the Hunter. Its brightest stars form one of the best known celestial shapes, which is visible even from cities. The plane of the Milky Way clips the northeast corner of the constellation and manifests itself as a featureless, hazy band through the neighboring constellations of Gemini and Monoceros. ☾ Orion's seven brightest stars are all 2nd magnitude or better. Most spectacular is Rigel, which shines at nearly magnitude 0 despite its great distance, just shy of 1,000 light-years. A 7th-magnitude companion to Rigel lies just 9" to the south. Betelgeuse is a red giant half as far away as Rigel. With an angular size of over 0.1", Betelgeuse's diameter would encompass the orbit of Jupiter. All three of Orion's "belt stars" are blue-white suns of very similar spectral types. On transparent nights, look for the large number of 6th- and 7th-magnitude stars clustered around the belt.

We begin observing in Orion with an unlikely target. The tiny planetary nebula **J320** was discovered by French observer Robert Jonckheere in 1916. It is bright enough to be visible through a 6-inch telescope, but picking it out from the star field can be a challenge. "Blinking" the field with a nebula filter will cause the almost star-like disk of J320 to pop into view. In my 10-inch scope at 250x, the circular disk appears 5" across with a bright center.

A pan of nearly 10° due south brings a bright carbon star into the field. At its brightest, **W Orionis** is easily found with a finder scope, but it fades as faint as 12th magnitude over a period of 214 days. Large-aperture telescopes reveal its ruddy hue, which is best detected using direct vision. The color of this cool star comes from its sooty outer layer.



ORION is easily recognized thanks to its bright stars, especially the three in a row that serve as the Hunter's belt. ALAN DYER

Tom Polakis *lives in Arizona, where he is an aerospace engineer by day and a deep-sky observer and astrophotographer by night.*

Two degrees north of the 3rd-magnitude star Beta (β) Eridani lies the reflection nebula **NGC 1788.** In a 10-inch scope, it looks bright and measures 3' by 2'. The nebula has two lobes; the western lobe surrounds a 10th-magnitude star while the eastern lobe has a small, bright concentration of light at its center. The edge of the nebulosity is diffuse, and the south end meets dark nebula LDN 1616, which is apparent from the lack of background stars over a 5-arcminute-wide region. NGC 1788 hosts ongoing star formation and is illuminated by a small cluster of stars hidden from view.

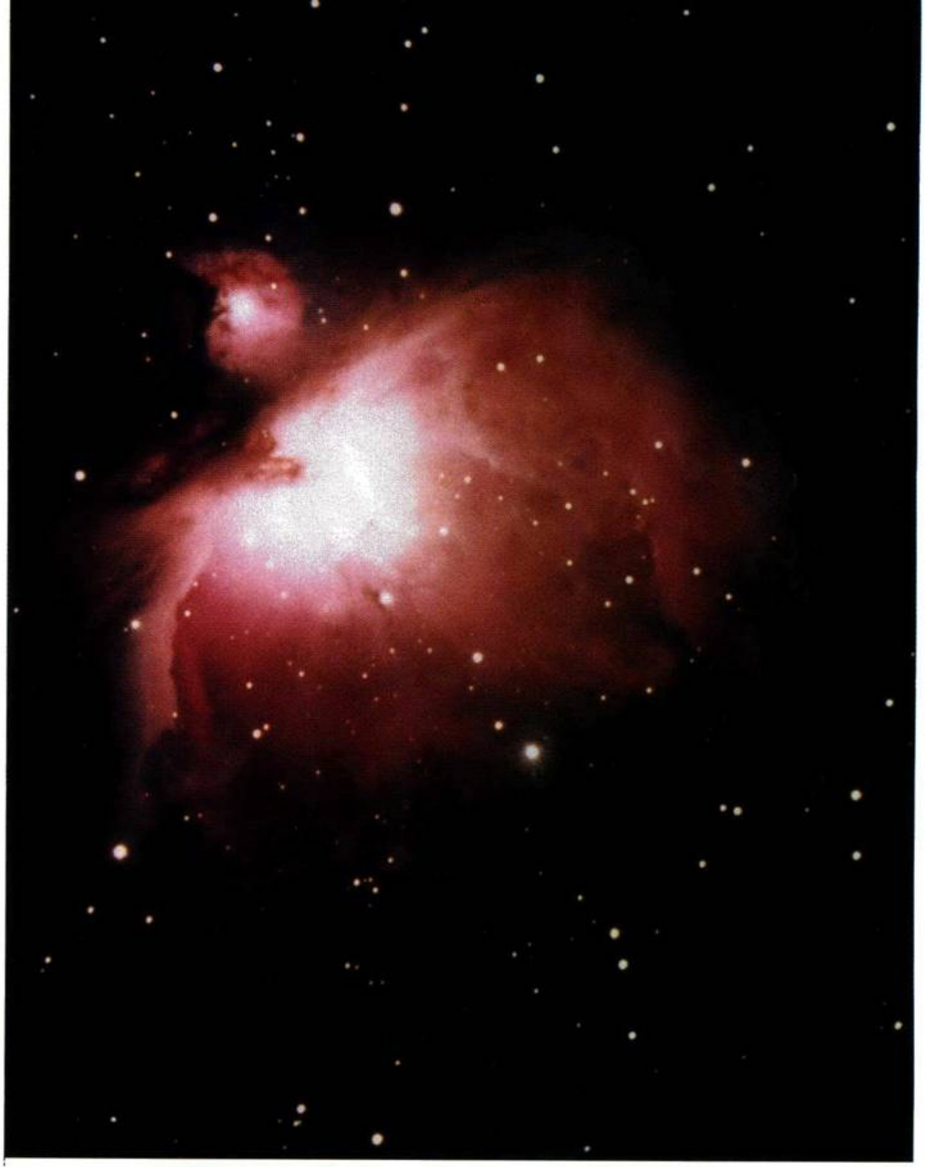
Although Orion holds plenty of alluring targets, telescopes seem to be magnetically attracted to **M42 (NGC 1976)**, the Orion Nebula. Let's begin by investigating the scene with a small, rich-field scope. Between two pairs of bright stars sits a cloud that appears to have two curved wings and a very bright clump of stars near its center. Increasing the aperture and magnification shows this stellar group to be the Trapezium, which includes four bright, young stars born from the nebula. Just to the east of the Trapezium, a bright, scalloped bar embeds itself in the haze. When viewed through a larger scope, the curved wings can be traced around to meet each other, forming a full circle.

Large telescopes reveal two more stars in the Trapezium and show a field filled with mottled detail. The eastern wing has a ruddy appearance — one of the few deep-sky objects bright enough to show its red color to visual observers. The Orion Nebula is brightest around the Trapezium, where it shines with a lime-green tint. Protruding into the glowing region is the dark "fish mouth" of obscuring material that borders the nebulosity.

As with most of the nebulae in the vicinity of Orion's belt, M42 is 1,500 light-years away and just a small enhancement in a giant molecular cloud. Embedded in the nebulosity is the Orion Nebula Cluster, a gathering of more than 4,000 stars with an average age of only one million years.

Because it's the closest region of active star formation, M42 has been well studied. Astronomers have found more than a hundred proplyds (accretion disks surrounding young stars) in the Orion Nebula. Some of these stars discharge high-velocity jets of gas, creating shock waves in the surrounding medium.

Although **M43 (NGC 1982)** has its own designation, it's difficult to consider it a distinct object from the Orion Nebula. A circular halo about 4' in diameter, M43 appears just north of the "fish mouth" feature of M42. Look for a sharp truncation, caused by a dark nebula, along the eastern edge of the round haze. Telescopes show the bright variable star NU Orionis at the center of M43. Shining at a relatively constant 7th magnitude, this star varies by only 0.1 magnitude.



THE ORION NEBULA glows brilliantly as the middle "star" in Orion's sword. Also known as M42, the famous nebula seems to be connected to the smaller M43 to the north. FABIO FALCHI

/// THE HUNTER

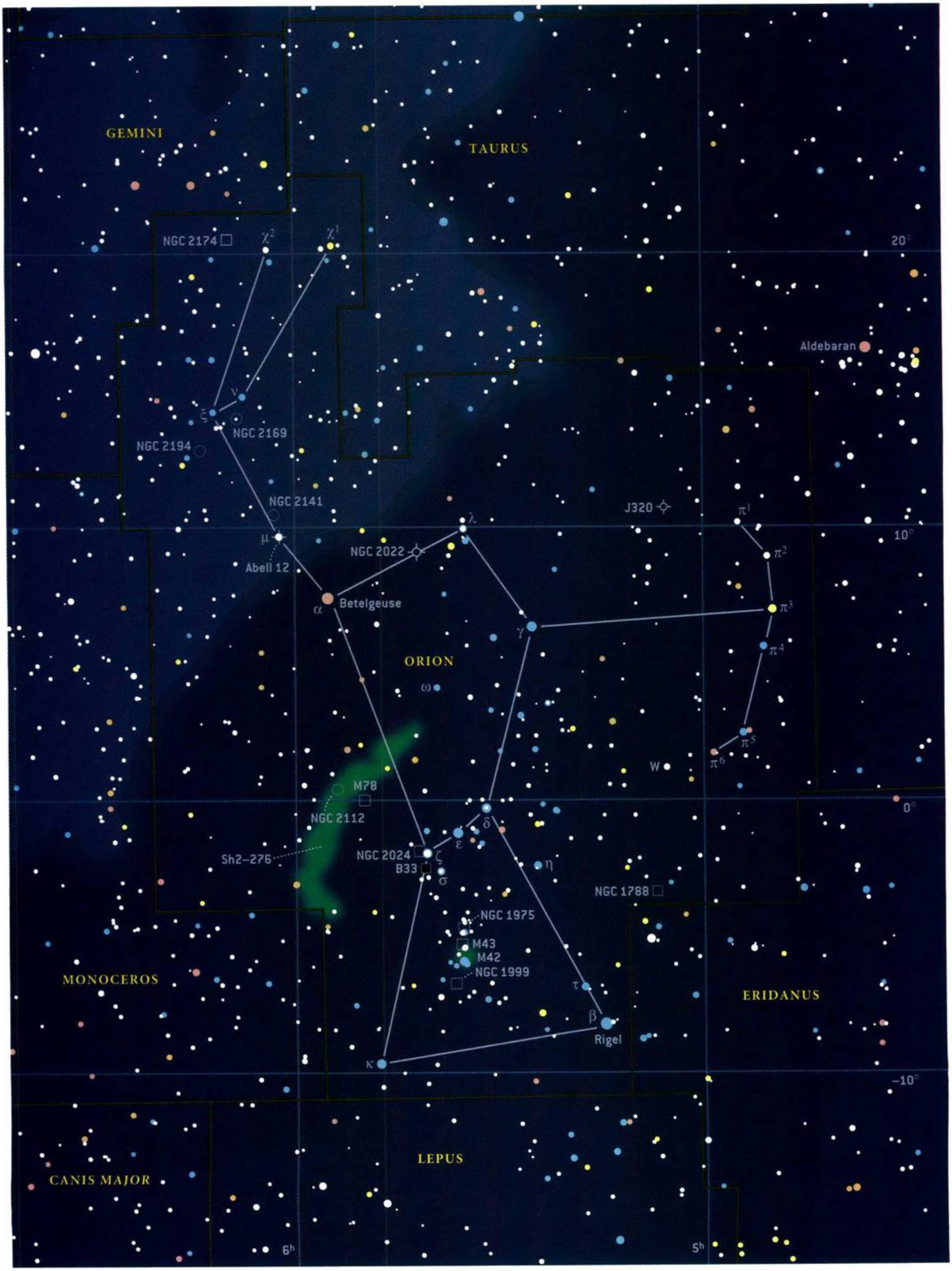
The moon is bright, and the winds are laid,
and the river is roaring by;
Orion swings, with his belted lights
low down in the western sky.
In the Moonlight, *David McKee Wright (1869–1928)*

Perhaps the most recognizable constellation, Orion is familiar even to the most casual astronomers. The appearance of a hunter is unmistakable: a group of stars forming a head, four bright quadrilateral stars marking shoulders and knees, three aligned stars constructing his belt, a fainter line of stars (and a bright nebula) outlining a sword, an extended collection of fainter stars imitating a raised club, and a bowed string of stars modeling as a shield.

Ancient stargazers also identified the celestial figure as a man. Egyptians revered the celestial profile as either the god of light, Horus, or his father, Osiris; while the Sumerians and Babylonians linked the stellar body with the king of Uruk, Gilgamesh. In fact, the Sumerian name Uru-anna (light of the sky) resembles the constellation's contemporary name. That culture's association of Orion with mighty Gilgamesh also accounts for the Hunter's eternal struggle with Taurus the Bull: Gilgamesh fought a bull when a scorned admirer ordered the animal to destroy Uruk.

A popular legend retold by many throughout history, the Greek account of Orion's life and death varies with the storyteller. One popular adaptation involves the huntress Artemis, who fell in love with Orion. Artemis's brother, Apollo, disapproved of the couple, though. One day, he spotted Orion swimming in the distance and challenged his sister to hit the faraway, floating object with an arrow. Artemis was skilled, and she struck the target on her first attempt. She was devastated when Orion's body washed ashore and she realized what she had done.

Other accounts blame Orion's demise on a scorpion. In one version, Orion boasted he could kill any beast on Earth and subsequently was attacked and killed by the scorpion. Another story claims that a scorpion was chasing Orion when he jumped into the water to escape it. It was then that Apollo pointed out the bobbing target to Artemis. In Greece, Orion sets into the western sea when Scorpius the Scorpion rises in the east. — *Vanessa Thomas*


GEMINI
TAURUS
NGC 2174
χ2
χ1
20°
Aldebaran
ν
ξ
NGC 2169
NGC 2194
NGC 2141
J320
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λ
μ
10°
NGC 2022
π2
Abell 12
Betelgeuse
α
π3
γ
π4
ORION
ω
π5
π6
W
M78
0°
NGC 2112
δ
ε
NGC 2024
ζ
Sh2-276
B33
σ
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NGC 1788
NGC 1975
M43
M42
NGC 1999
MONOCEROS
τ
ERIDANUS
β
Rigel
κ
-10°
LEPUS
CANIS MAJOR
6h
5h

THE FLAME, HORSEHEAD, RUNNING MAN, AND ORION NEBULAE pack an amazing, colorful punch into a relatively small area and repeatedly seduce observers into Orion's sword region. JOHN A. VOLK

BARNARD'S LOOP, or Sh2-276, wraps around the eastern side of Orion's torso. GERALD RHEMANN

A half degree north of the Orion Nebula, **NGC 1975** highlights a complex of reflection nebulae sometimes called the Running Man Nebula. Through a 13-inch scope, NGC 1975 appears as an elongated, bright nebula with a mottled texture. The 5th-magnitude stars 42 and 45 Orionis are embedded in a dark rift that divides two prominent strips of nebulosity.

Slightly more than 1° south-southeast of M42 lies the reflection nebula **NGC 1999**, which would be rather ordinary were it not for a dark obscuration near its center. This feature initially creates the impression of a ring-shaped planetary nebula, but increased magnification shows the dark nebula's triangular form. Just outside the dark cloud sits V380 Orionis, a variable star that illuminates this reflection nebula.

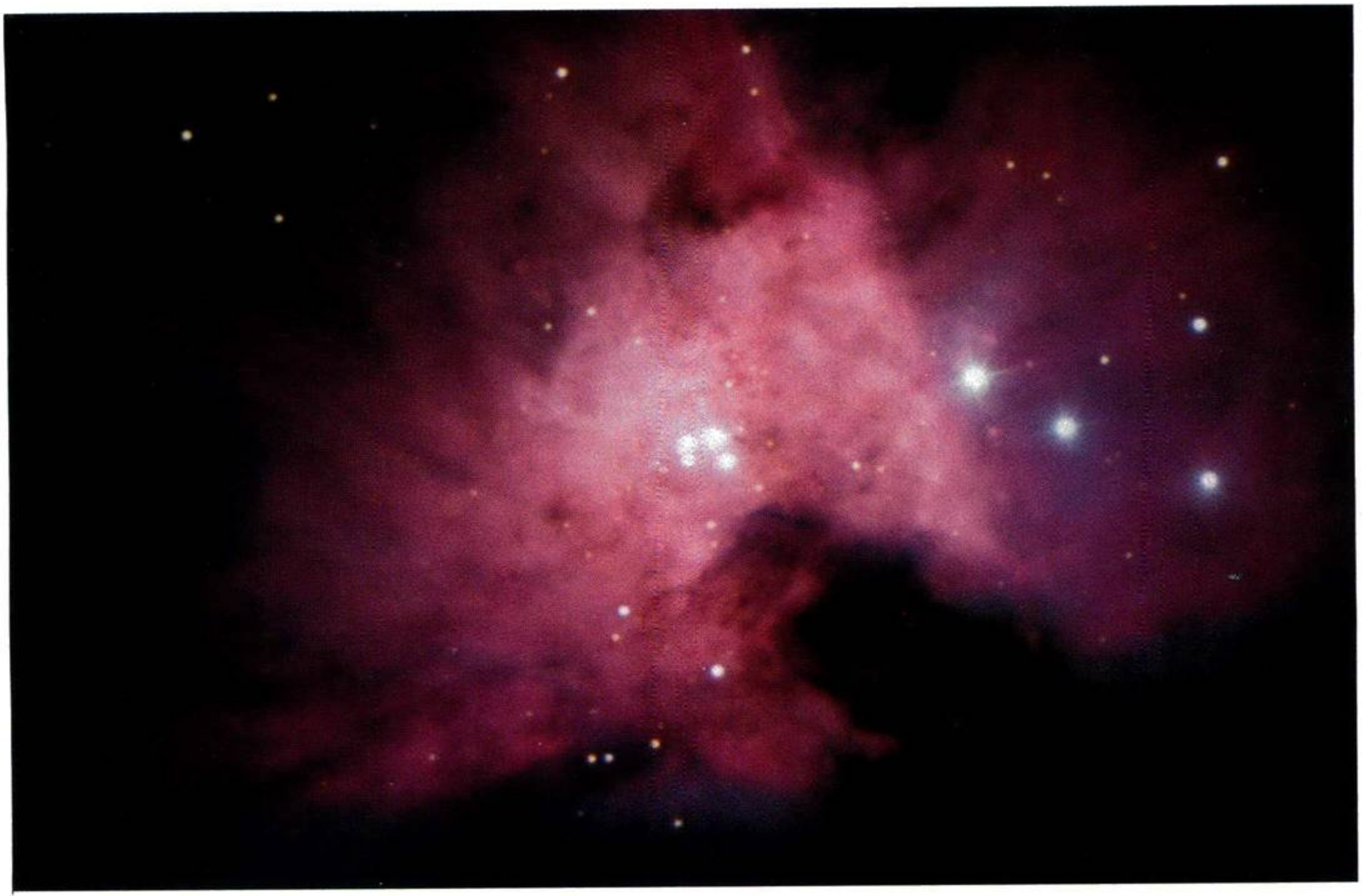
/// Deep-sky objects in Orion

OBJECT	R. A.	DEC.	MAG.	SIZE	TYPE	NOTES
W Orionis	5h05.4m	1°11'	6.2	—	Star	Carbon star
J320	5h05.6m	10°42'	12.0	26"	PN	—
NGC 1788	5h06.9m	–3°21'	—	5' by 3'	BN	—
NGC 1975	5h35.4m	–4°41'	—	10' by 5'	BN	—
M42 (NGC 1976)	5h35.4m	–5°27'	—	65' by 60'	BN	Orion Nebula
M43 (NGC 1982)	5h35.6m	–5°16'	—	20' by 15'	BN	—
NGC 1999	5h36.5m	–6°42'	—	2' by 2'	BN	—
B33	5h40.9m	–2°28'	—	6' by 4'	DN	Horsehead Nebula
NGC 2024	5h41.9m	–1°51'	—	30' by 30'	BN	Flame Nebula
NGC 2022	5h42.1m	9°05'	11.9	39"	PN	—
M78 (NGC 2068)	5h46.7m	0°03'	—	8' by 6'	BN	—
Sh2–276	5h48.0m	1°00'	—	600' by 30'	BN	Barnard's Loop
NGC 2112	5h53.9m	0°24'	8.4	11'	OC	—
Abell 12	6h02.3m	9°39'	12.0	37"	PN	—
NGC 2141	6h03.1m	10°26'	9.4	10'	OC	—
NGC 2169	6h08.4m	13°58'	5.9	6'	OC	—
NGC 2174	6h09.7m	20°30'	—	40' by 30'	BN	—
NGC 2194	6h13.8m	12°48'	8.5	8'	OC	—

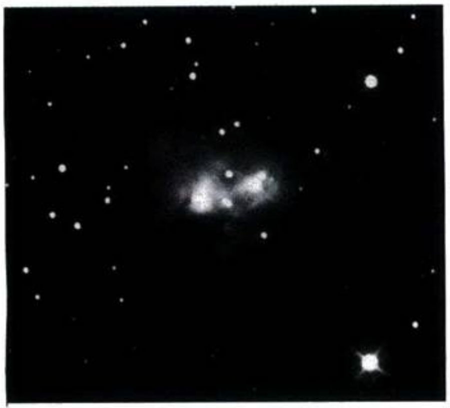
Object: Designation in Messier, NGC, or other catalog. **R. A. and Dec.:** Right ascension and declination in epoch 2000.0 coordinates. **Mag.:** Visual magnitude. **Size:** Size in arcminutes or arcseconds.

The bright emission nebula **NGC 2024**, or the Flame Nebula, resides too close for comfort to the glare of Zeta (ζ) Orionis. A magnification of around 100x proves high enough to remove the star from the field but low enough to show the entire nebula. NGC 2024 resembles a U shape with squared edges. A nebula filter shows the edges' complexity, which gives rise to the flame moniker. Like many of our objects, NGC 2024 lies in the Orion Molecular Cloud at a distance of 1,500 light-years. The ionizing source for the emission nebula is visible only at infrared wavelengths.

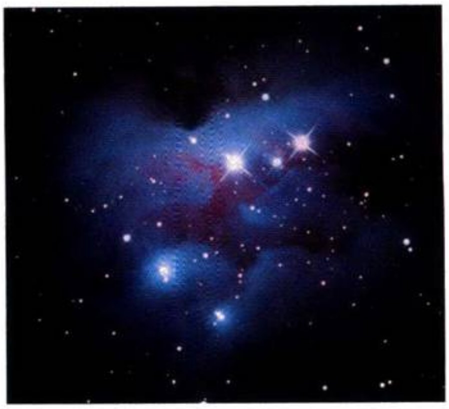
Panning 30' south of Zeta Orionis brings a popular star-party target into view. Dark nebula **Barnard 33 (Horsehead Nebula)** has twenty-seven times more mass than the Sun and is similar in structure to the "elephant trunks" of the Eagle Nebula. We see the Horsehead only because it is silhouetted against IC 434, a background emission nebula (the brightest part of which measures 15' by 5'). Look first for a dark feature 5' in diameter superimposed on this bright nebula. The horse's shape becomes apparent in apertures of around 10 inches and at magnifications greater than 100x. Use a filter that allows the H-beta emission band to pass through, such as a wide-band nebula filter or a specialized H-beta filter.



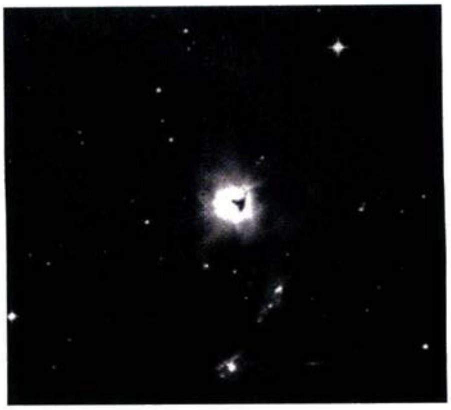
THE TRAPEZIUM REGION at the center of the Orion Nebula (M42) holds a stellar cluster dominated by four bright, young stars born within the nebula. A dark bar (forming the bottom "lip" of the "fish mouth") protrudes into the bright nebula and points out the Trapezium stars. TONY HALLAS



NGC 1788 is a double-lobed reflection nebula near Orion's border with Eridanus. A dark nebula lurks to the south. PRESTON SCOTT JUSTIS



NGC 1975 forms an interesting complex of reflection nebulae with NGCs 1973 and 1977. Some call the group the Running Man Nebula. ANDREW PETERS



NGC 1999 may look like a ring nebula at first, but closer inspection will reveal a dark, triangular nebula obscuring its center. DSS/POSS2/UKSTU

To the north and east of Barnard 33, you'll find **M78 (NGC 2068)**, one of the sky's brightest reflection nebulae. The two most vivid concentrations in this nebula bracket an 11th-magnitude star. In a 13-inch scope, M78 spans 5', showing an abrupt northwestern edge and an ill-defined southern edge. A dark lane divides M78 from the much fainter mist of NGC 2067 to the northwest. A quarter degree to the north lies NGC 2071, which adds another reflection nebula to the scene. Backing off to the lowest magnification reveals a gray and mostly starless background, indicative of an associated molecular cloud.

Sh2-276 (Barnard's Loop) appears best through a rich-field telescope. The nebula's main strip is some 6° long and tapers at the northwestern end. My 8-inch f/4 at 30x brings out a slight enhancement to the field's brightness when a nebula filter is in place. Binoculars may be better than a rich-field instrument because they can take in a good part of the loop. Deep photographs show a true, circumscribed loop covering much of the constellation.

The brightest part of Barnard's Loop is found around star cluster **NGC 2112**. This cluster contains about twenty-five stars — most of them faint — across an area 8' in

THE FLAME NEBULA (NGC 2024) has branches of nebulosity that lick the sky just as campfire flames reach into a cold night. Zeta Orionis lies beyond the bottom edge of the frame. A. TREMBLY, JR.

THE HORSEHEAD NEBULA, or Barnard 33, is perhaps the most distinctive dark nebula and a favorite of astrophotographers. JACK NEWTON

M78 (upper right) overwhelms the dimmer mist of NGC 2067 while NGC 2071 holds its own a bit farther away (lower left). KIM ZUSSMAN

NGC 2174 is a vivid emission nebula near the tip of Orion's club. A 7th-magnitude foreground star lies over its heart. GEORGE GREANEY AND DEAN EASTON

diameter. The cluster is loose and scattered but has a strong background glow hinting at the presence of dozens of unresolved stars. NGC 2112 lies 2,800 light-years away from us and 600 light-years above the galaxy's plane.

Moving northward, we find a bright target for an 8-inch scope: planetary nebula **NGC 2022**. Using a magnification of 300x, the nebula's 15" disk has a hazy edge. A larger instrument begins to reveal a dark center, implying a ring structure. The central star is magnitude 14.8 and out of view for most observers.

Pan your scope 3° northeast of Betelgeuse to find Mu (μ) Orionis. With a nebula filter, you should be able to spot the disk of planetary nebula **Abell 12**, which appears to touch the bright star. The filter suppresses the star's glare and darkens the surrounding sky. Using the highest magnification that the seeing permits, the disk will appear 15" across and reveal hints of annular structure.

Open cluster **NGC 2141** lies less than a degree north of Abell 12. A faint object overall, the cluster becomes well defined through larger scopes, which show dozens of equally bright stars at the limit of detection. When viewed through smaller scopes, these stars manifest themselves as a background haze with a sharp edge 10' in diameter. At 2.5 billion years old, NGC 2141 is an ancient cluster that lies 12,000 light-years away.

Continuing north and west, we come upon **NGC 2194**, a fine open cluster containing several dozen stars. An assortment of stars between magnitudes 10 and 13 are spread over an area 6' across. Look for a concentration of 11th-magnitude stars at the cluster's heart. Approximately 10,000 light-years separate us from NGC 2194.

At a dark site with unaided vision, an observer can spot open cluster **NGC 2169** as a tiny clump just west of Xi (ξ) Orionis. The cluster spans only 5' across, but it contains seven stars brighter than 9th magnitude. It is not spectacular telescopically, but the brightness of its members gives it an easily recognizable form against starry Milky Way fields.

The bright emission nebula **NGC 2174** perches near Orion's border with Gemini. Situated in a rich field, the nebula appears 12' across and perfectly circular. It has a diffuse edge but is otherwise uniform. A 7th-magnitude star appears to shine in the center of the nebula, but it's actually superimposed. The nebulosity is enhanced greatly with a nebula filter. ◼

EQUIPMENT ROUNDUP

The latest binoculars and telescopes are showcased in the shadow of Mt. Fuji.

/// TEXT AND PHOTOS BY BARRY KAWA

Japan's telescope show

Mars was coming. With visions of polar caps and martian clouds floating through my mind, I caught the train on June 21, 2003, to Japan's annual Telescope and Binocular Show in Tokyo. A gathering of the Japan Telescope Manufacturers' Association (J.T.M.A.), 2003's show was held in the Tokyo Industrial Trade Center.

My wife accompanied me as my translator and the formidable guardian of our budget, in case I spotted my dream scope. Like most amateur astronomers, I felt "aperture challenged" as I salivated over Mars's close approach in late August 2003. My 3-inch Takahashi FC-76, although a superb performer, seemed undersized for the once-in-a-lifetime viewing opportunity. Japan's savvy telescope manufacturers stoked that lust at the show and in the pages of the popular Japanese astronomy magazine *Temmon Guide*, a thick monthly filled with endless pages of telescope ads and JPL-quality shots taken by amateurs.

"Mars fever" seemed to be infecting many attendees. But the mood at this year's show also seemed somewhat subdued, mirroring the stagnant Japanese economy that has been hit hard by years of deflation and the recent government bailout of struggling banks.

New beginnings

At the entrance to the show, two uniformed greeters handed visitors a 448-page Photo Expo 2003 catalog, which confirmed rumors that the J.T.B. Show would end after twenty-five years. Next year, the show will merge with the giant Photo Expo 2004, which will be held March 14–16 at the larger Tokyo International Exhibition Center. Each year, the J.T.B. Show draws between four and five thousand participants to the two-day event. The Photo Expo attracts about eighty thousand in comparison.

J.T.B. Show 2003
Japan Telescopes and Binoculars Show
日本 望遠鏡・双眼鏡ショー
講演会場スケジュール
6月21日(土)
6月22日(日)
受
付

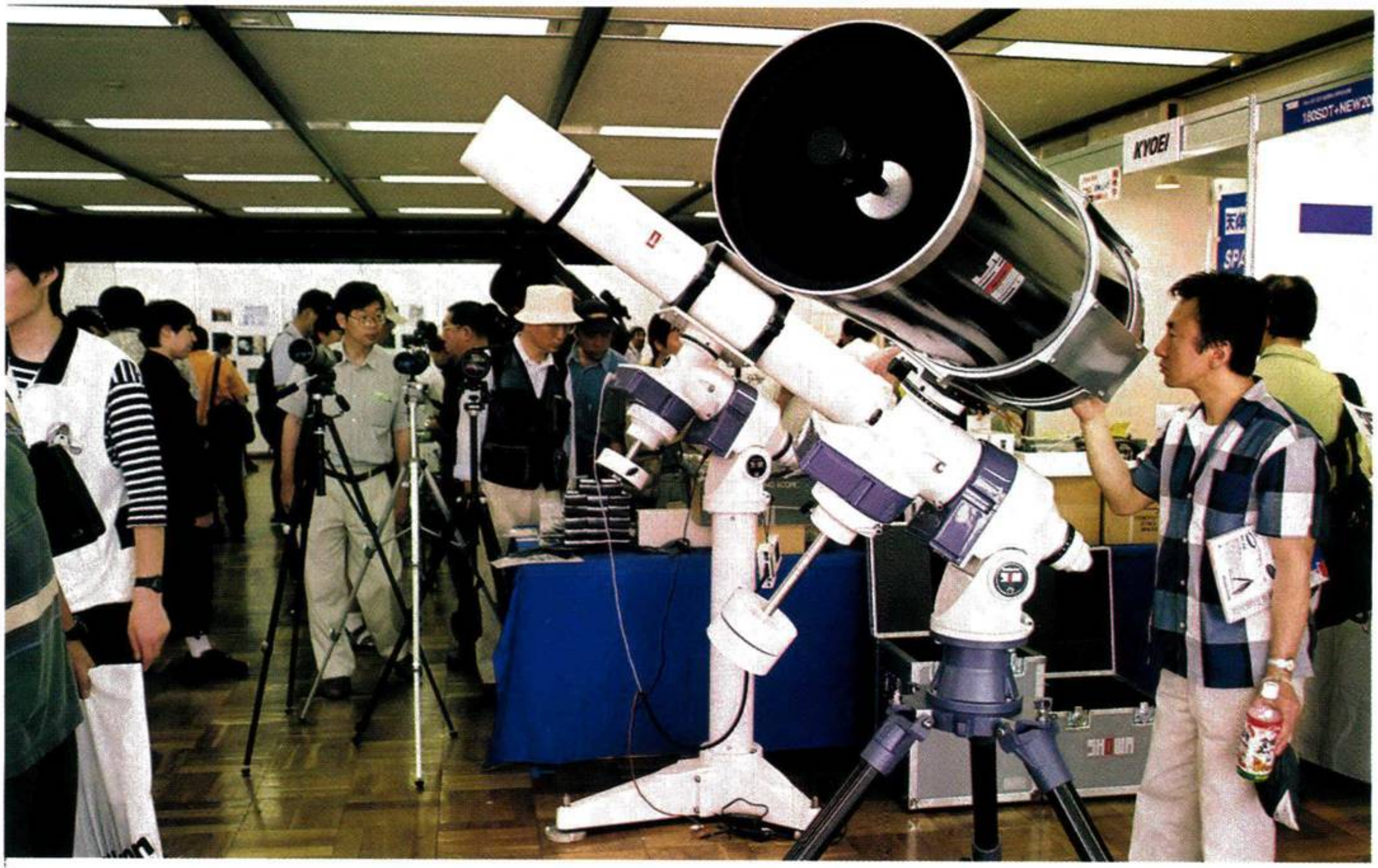
UNIFORMED GREETERS assisted guests and ensured things ran smoothly at the Japan Telescope and Binocular Show held at the Tokyo Industrial Trade Center.

"I'm sad that this is the last year," said attendee Nozomu Muto, as he headed over for his first look at Takahashi's new TOA-130, a 5-inch apochromatic refractor. The association's executive director, Shigeru Kobayashi, confirmed that attendance has been stagnant the past few years while the number of members in the J.T.M.A. has declined. Two notable non-members are telescope giant Vixen Optical and binocular manufacturer Miyauchi. So, Kobayashi figures the change of venue will be a positive move, especially because many of the attendees are interested in photography as well as astronomy.

Unlike a show in the United States, the J.T.B. gathering isn't centered on a star party, swap tables, or lectures with big-name speakers. It's simply a venue for manufacturers to introduce their new product lines to a gathering of astronomy buffs and bird-watchers. Attendees come to see old friends and bring digital cameras to snap pictures of virtually everything in sight. And admission is free.

A special deal

Although no used scopes were for sale, manufacturers Kenko and Borg had small tables where they sold new eyepieces and other parts at bargain prices. One enterprising telescope store also sold eyepieces, small optical tubes, and binoculars from a variety of manufacturers.

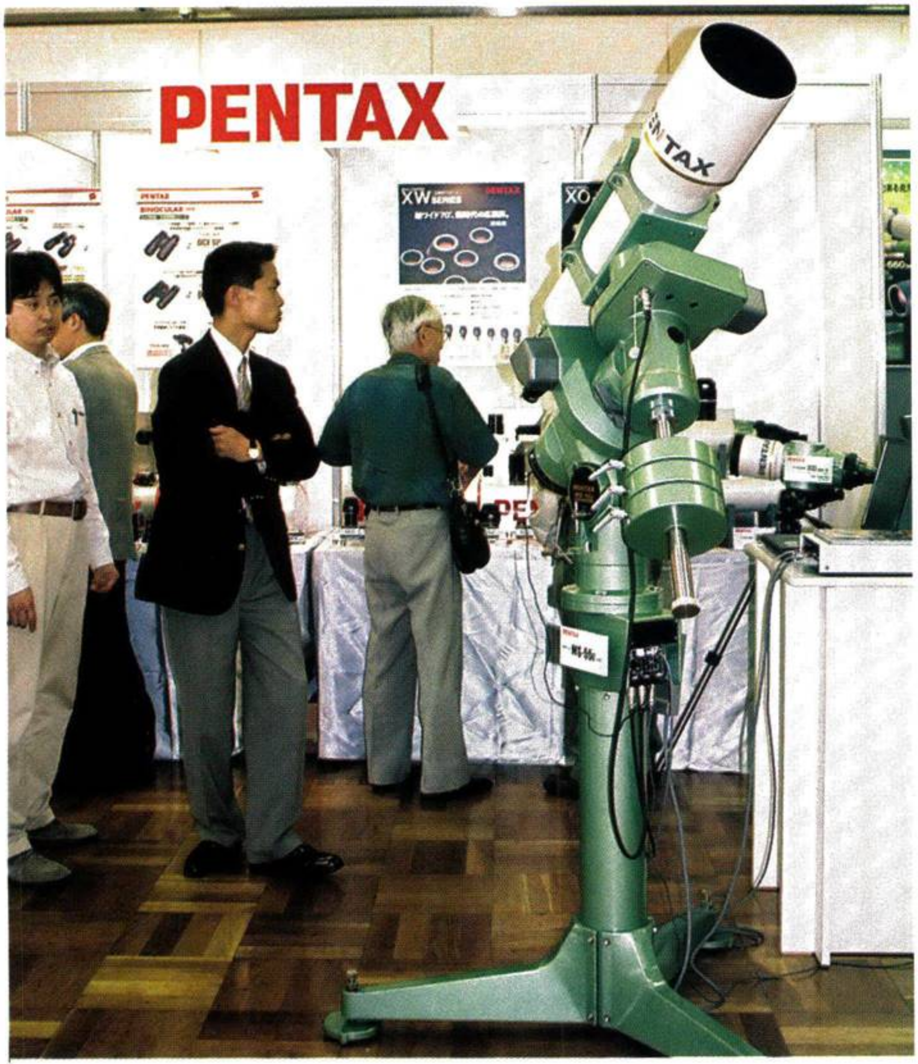


TWO SHOWSTOPPERS were Showa's 14-inch Dall-Kirkham Cassegrain and their 6-inch f/8 fluorite triplet achromatic refractor, each mounted on massive equatorial mounts.

AstroArts, a Japanese astronomy software and magazine publisher, offered an interesting product: Having purchased twenty Vixen 4-inch f/15 achromatic lenses, the company produced a "Mars Project Limited Edition" telescope. Visitors certainly will remember the show's last year as the year of Mars. Selling for a show special 60,000 yen (about $520), the gargantuan optical tube assembly looked very tempting.

"We're selling it for Mars," said Haruki Kamiyama, AstroArts director. Kamiyama said he observed Jupiter with the scope and thought it performed excellently, producing a natural-looking image with good detail. Still, the tube dwarfed the mount it was on. On my much shorter mount, I'd have to dig a deep hole to look at anything near the zenith. AstroArts even offered to ship it to my home free of charge so I wouldn't have to jostle my fellow subway passengers with a 5-foot metal tube. As I counted the yen in my wallet and figured out the exchange rate in U.S. dollars, my wife frowned and led me away.

PENTAX'S NEW LINE of XO orthoscopic and XW 70° apparent field of view eyepieces drew rave reviews from observers for their eye relief, feel, and high light throughput.



A PENTAX 150 SDP 6-inch apochromatic refractor with a four element lens of SD glass attracted a great deal of attention perched atop a "secret" MS55Z equatorial mount and pier.

MANY ATTENDEES took advantage of Kenko's odds-and-ends table, buying goodies such as eyepieces, filters, and tripod adapters.

What's new?

Nearby, Takahashi's optical designer Toshinori Yuyama gave a brief presentation on his company's new TOA-130, a triplet apochromatic refractor utilizing two ED lenses. ED stands for "extra-low dispersion" and refers to the glass out of which the lens elements are made. About eighty attendees, mostly middle-aged men, watched the slide presentation of radial curves, which explained the "amount of color is zero."

Afterward, at the Takahashi booth, general manager Iwao Henmi confirmed the hot-selling TOA-130 is just the first in a series of new telescopes. As I watched someone gingerly lifting the 20-pound tube up on the pier mount, I wondered aloud if the company might produce a lighter model that wouldn't give my smaller Takahashi mount a backache. "It's a secret," Henmi smiled, saying there was a plan but he was not ready to announce it. He did say that Takahashi someday plans to discontinue its current FS series because the lens is environmentally unfriendly. This caused my wife to flip through her Japanese-English dictionary looking for the equivalent of "lead."

Not wanting to be environmentally unfriendly, I asked about his company's Mewlon scopes. Starbase Tokyo, which sells Takahashi scopes, has been running an eye-catching campaign touting the Mewlon series, which employs a Dall-Kirkham optical design, as the perfect scope for viewing Mars. Takahashi displayed 7-inch Mewlon 180 and 10-inch Mewlon 250 models at the show, which certainly raised the lust factor. But Henmi said the campaign worked so well that both Mewlons have been on back-order for months.

Across the aisle, Pentax representatives were kept equally busy because everyone wanted to see the new line of Pentax eyepieces. The eyepieces went on sale June 20, 2003, in Japan, just in time for prime Mars viewing. But Pentax employees were not sure when they would be available in the United States. Pentax's discontinued line of .965" SMC orthoscopics is renowned for containing some of the finest planetary eyepieces ever made.

Pentax's new XO orthoscopic line includes all 1.25" eyepieces, which is more in line with the growing trend in Japan to use the larger size. Pentax's new XW series sports a wider 70° field of view compared to the former XL's 65° field. The eyepieces certainly drew a crowd, with everyone stopping to check out eye relief (which is tight, at less than 4mm) and light output. Pentax's XW series starts at 36,000 yen ($310) for the 3.5mm and peaks at 60,000 yen ($520) for the 40mm.

Another looker was the Pentax 150SDP 6-inch refractor perched high atop a futuristic-looking MS55Z mount. (The mount is still in design, so it may not be exactly the same when it's released.) Among the other scopes on display, Celestron's mammoth 14-inch Schmidt-Cassegrain CGE and its NexStar series brought many kudos from showgoers.

Barry Kawa *is a former U.S. journalist and current telescope buff now living in Japan, where he works for a newspaper.*

2003年 夏のボーグ新製品
TOMY
BORG 101 ED
BORG 77

BORG'S NEW REFRACTORS, a 4-inch f/6.3 and a 3-inch f/6.5, were displayed like jewels under glass. Built for portability, the scopes weigh only 5 and 3 pounds, respectively.

But it was Showa, maker of high-grade observatory telescopes and mounts that brought the richest eye candy — a 14-inch Dall-Kirkham reflector and a 6-inch f/8 fluorite triplet apochromatic refractor. The Dall-Kirkham tube assembly alone costs 1.8 million yen ($15,600), putting it in the ranks of rich, serious amateurs.

Across the way, Borg offered more affordable options. Borg had its two new "jewels" under glass: the upcoming 4-inch f/6.3 apochromatic and 3-inch f/6.5 achromatic refractors. Like all Borg scopes, these two are easily portable. The 4-inch tips the scale at a svelte 5 pounds, and the 3-inch at just more than 3 pounds. The new models are geared more toward the visual observer than the astrophotographer.

タカハシ
TOA-130
System

TWO TAKAHASHI MEWLON scopes were on display, the 10-inch Mewlon 250 (left) and the 7-inch Mewlon 180. Unfortunately, both models are on back-order for months.

"People are more interested in observing than photography," said Noboru Nakagawa of Borg's sales department. Indeed, many attendees were more interested in spotting birds than deep-sky objects or Mars. Not wasting this opportunity, companies like Zeiss, Kowa, Nikon, and Fujinon had their top-of-the-line spotting scopes and binoculars on hand.

In one section of the exhibition, a dream team "play area" offered a side-by-side lineup of Nikon 20x120 and Fujinon 25x150EM giant binoculars, an 82mm Kowa Prominer High Lander telescope, and Takahashi Sky 90 and Pentax ED spotting scopes. Attendees could peer through the Trade Center's windows into empty office buildings and even a high-rise apartment building where tenants had hung their laundry to dry on their balconies. "Those poor people," my wife said, as I tested the Fujinon's color correction on some unsuspecting family's wash.

At the end of the day, my search for the perfect Mars scope would continue. Although I escaped my wife's clutches and headed over for another gander at the 4-inch f/15, I realized what was missing — curb appeal. The Japanese love their scopes emblazoned with huge manufacturer decals like Pentax or Takahashi in Japanese letters across the OTA. I'm no different. This one might have found a loving home atop my EM-2 if AstroArts simply would have slapped a 50-yen "VIXEN" decal across the tube.

A "DREAM TEAM" LINEUP of Nikon 20x120 binoculars, Fujinon 25x150EM giant binoculars, and a Pentax ED spotting scope enabled attendees to compare the equipment.

TAKAHASHI OPTICAL DESIGNER Toshinori Yuyama answers a question about his company's new TOA-130 apochromatic refractor, which uses a triplet objective.

But others found what they were seeking. Takuichiro Onishi, 40, of Saitama, stood by while his 7-year-old son Takeharu tried out the Takahashi Sky 90 spotting scope. Another attendee, Makoto Takahashi, 70, bought a small Borg telescope at the show to look at the Moon. At the Takahashi booth, Nozomu Muto came away impressed by the TOA-130. "Maybe I'll get the 6-inch model, if I can afford it," Muto mused.

All in all, the final Japan Telescope and Binocular Show was a success. On a personal note, after consultation with my wife, I went back the next day and purchased one of the "Mars Project Limited Edition" scopes from AstroArts. What a great performer! My dream of observing martian features has been realized.

For the history and future of this show, visit www.astronomy.com/toc

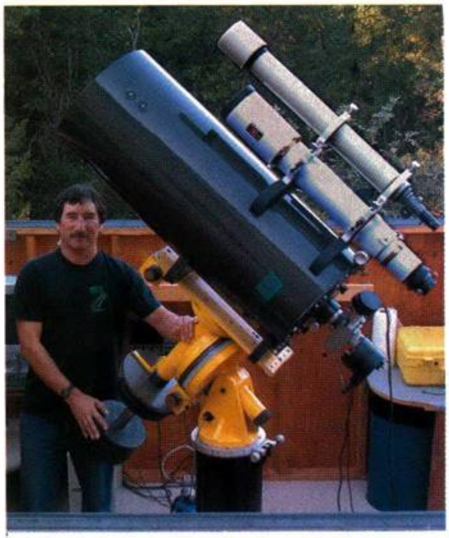
Follow these simple steps and your CCD images will have the quality of photographs.

/// TEXT BY TONY HALLAS; IMAGES BY TONY AND DAPHNE HALLAS

CCD images at their best

Today's amateur astronomers live by a new rule: Film is dead, and the digital age of CCD cameras is upon us. This transformation didn't happen overnight. To be honest, the first digital images taken by amateur astronomers weren't very good. Today, however, expectations are higher. We expect a digital image to look like a photograph.

For more than a decade, I've been exploring some of the concepts necessary to help amateur astronomers do this. My primary equipment is a Santa Barbara Instruments Group ST-10E CCD camera fastened to a 14.5-inch f/8 Astrographic Cassegrain telescope. But whatever equipment you use, don't expect the CCD to produce a good image by itself. Half the work occurs after you obtain the image. Post-processing — the "art" component of CCD imaging — is the key to transforming electronic data into photograph-like astronomical portraits.



TONY HALLAS in his private observatory, where the main instrument is a 14.5-inch Astrographic Cassegrain telescope.

Tony Hallas *is a self-taught astrophotographer who has captured the beauty of celestial objects since 1987.*

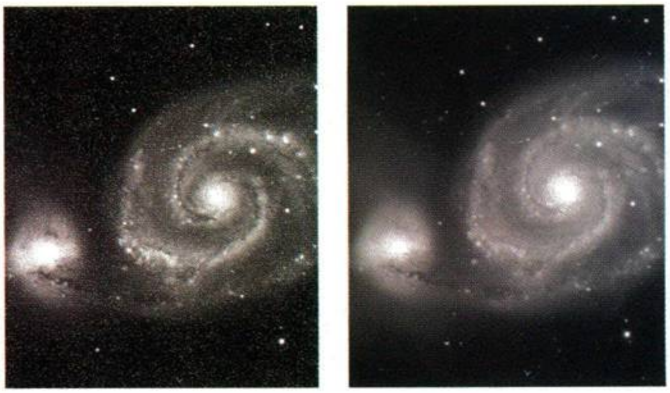
Discuss all aspects of CCD imaging at www.astronomy.com/toc

The cleanup begins

One of the major problems encountered with film during the 150-year history of its use by astronomers is "grain" — the exposed silver halide crystals that make up the developed image. The spacing of these crystals limits the resolution of the negative, the size to which the image can be reproduced, and the details that can be seen. CCD cameras also have resolution limitations, but a more severe problem is "noise."

A CCD camera works by focusing light onto an electronic chip, which is basically an array of sensors called "pixels." Because of inherent defects in the chip due to the manufacturing process, some of these pixels will produce false data that look like incoming light. In the jargon of CCD astronomy, they become "hot." Hot pixels show up as white spots all over an image, and our first step is to get rid of them.

Because hot pixels have nothing to do with the image, we can cover the camera and make an exposure of just these pixels. This exposure is called a "dark frame." The next step is to use software (generally provided by the camera's manufacturer) to convert all hot pixels to cold pixels of equal strength and subtract each from its corresponding hot pixel. (Because a CCD records digital data, this really is just a subtraction of one number from another.) The hot and cold information cancels out, leaving behind the real image. This step is called "dark subtract."

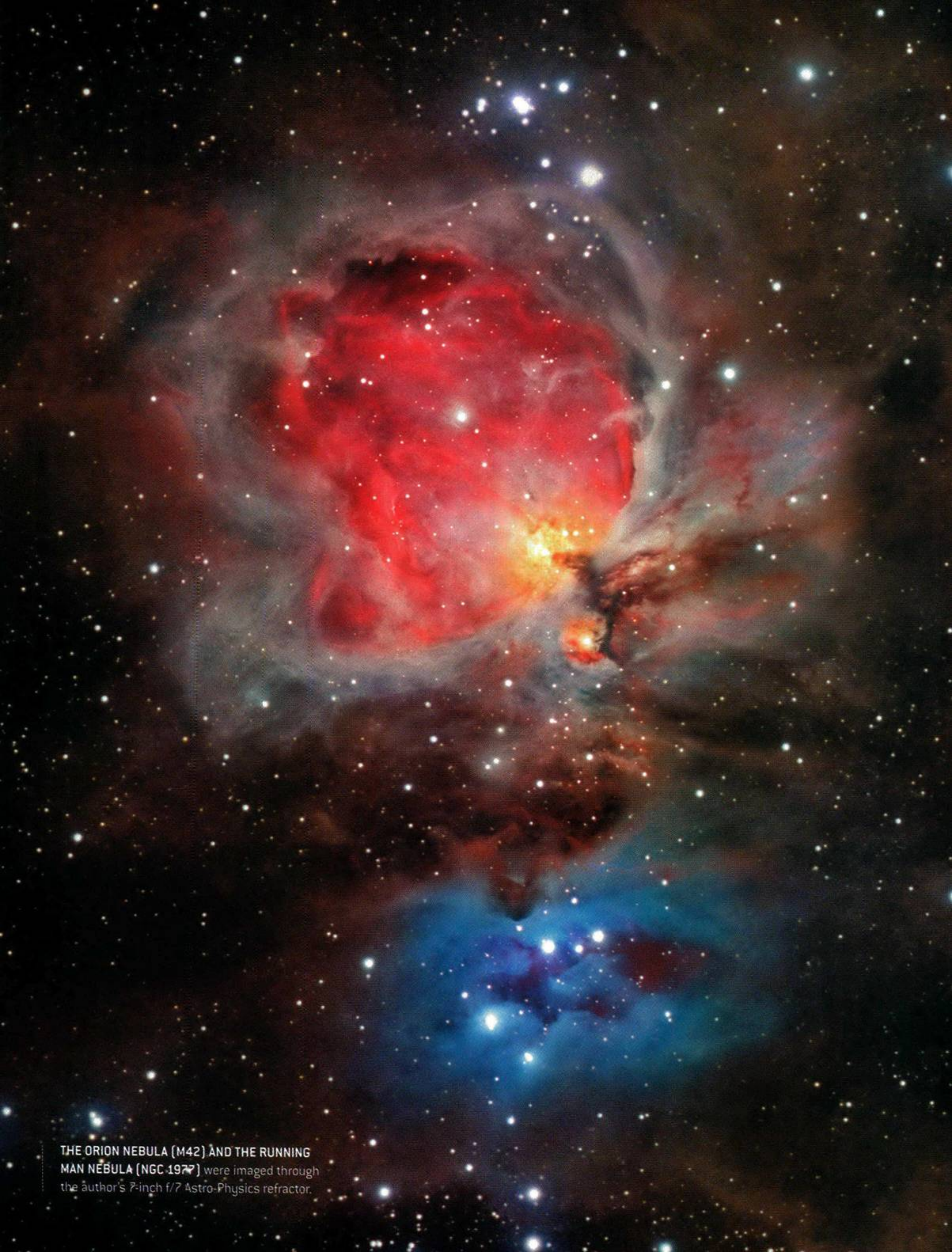


HOT PIXELS IN A CCD IMAGE (left) of the Whirlpool Galaxy show up as white spots. Eliminate hot pixels (right) by subtracting a dark-frame exposure.

Say "nay" to stray rays

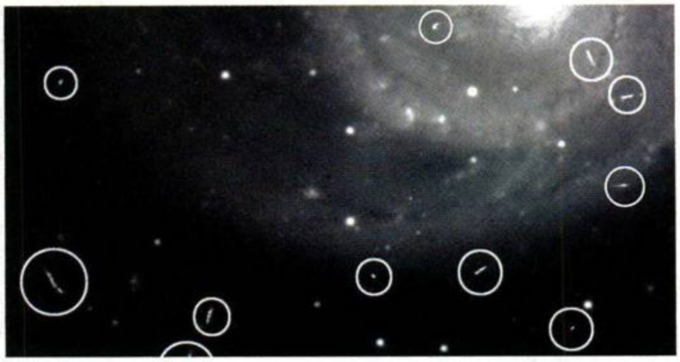
With our cleaner image, we now notice another significant source of noise. Sprinkled randomly across the image are small streaks and dots — the

Continued on page 86



THE ORION NEBULA (M42) AND THE RUNNING MAN NEBULA (NGC 1977) were imaged through the author's 7-inch f/7 Astro-Physics refractor.

THE PINWHEEL GALAXY (M33) in Triangulum was imaged with the author's 14.5-inch f/8 Astrographic Cassegrain reflector. This image actually was made on hypersensitized Kodak RG 200 print film, then the original negative was scanned and all post-processing was done digitally.



COSMIC-RAY HITS are revealed as bright spots randomly strewn throughout images of the galaxy; software compares images and removes the spots.

punctuation of outer space. CCD cameras are so sensitive they record cosmic rays striking the chip! Cosmic rays are energetic particles that originate from a variety of objects in space, including the Sun. We can't do a dark subtract to get rid of cosmic-ray hits because they're random in pattern. But this randomness gives us a way to eliminate them.

Let's take, for example, five similar pictures of a test object, the Whirlpool Galaxy (M51) in Canes Venatici. After performing a dark subtract to each frame to get rid of the hot pixels, there will be cosmic-ray hits sprinkled here and there. We can use software to identify the elements that are common to the five images so the computer has no problem identifying what doesn't belong. To the computer, cosmic-ray hits look like people dressed in blue jeans at a formal dinner, and once identified, they can be eliminated. This is called "median combining."

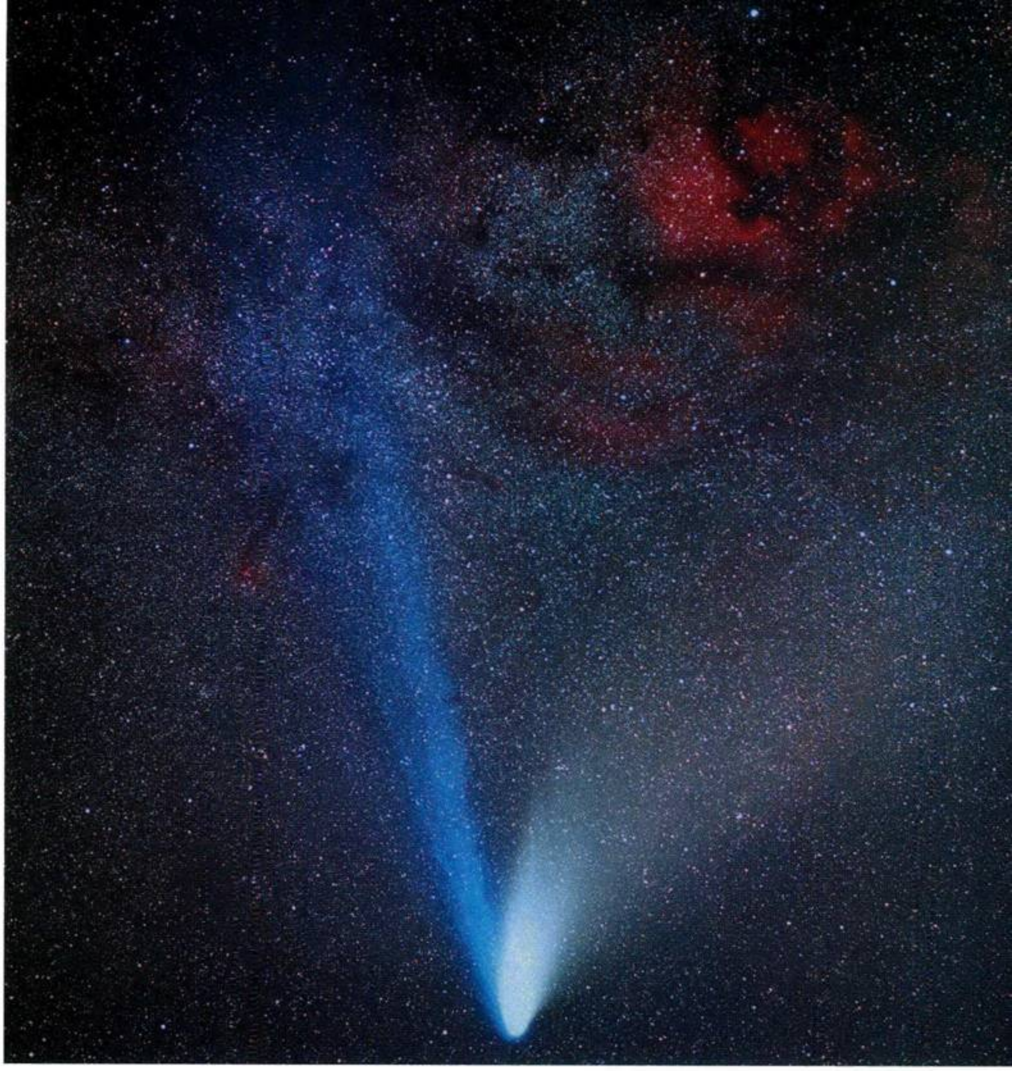
Data lost

Most quality CCD cameras now capture information in 14- or 16-bit mode, as opposed to the 8-bit mode of early models. This means more detail is captured in the image. "High bit depth" allows for better processing of the image after it is recorded because there's more information to work with. Linked to this is "dynamic range," which is (in numerical terms) how extreme — from light to dark — the CCD can record. When you combine high bit depth with good dynamic range you have the foundation for a great image. Were it only this simple. It's usually at this point that trouble begins.

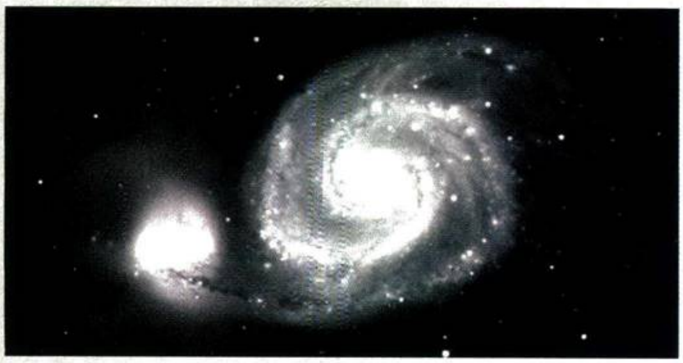
Knowing how to process the data from this point onward is paramount to achieving photo-realistic images. The number one mistake that leads to bad

THE DUMBBELL NEBULA (M27) in Vulpecula is an LRGB image of 100, 100, 80, and 160 minutes, respectively.

THE CRAB NEBULA (M1) is a composite of nine 12-minute CCD exposures.



COMET HALE-BOPP drifts past the North American Nebula (NGC 7000) in Cygnus. For this view, the author used a 165mm lens on a Pentax 6x7 camera with Kodak PPF 400 film and digital processing.



A CLIPPED IMAGE OF M51 shows no detail in the bright areas, and faint objects have faded to black and disappeared into the background.

processing is throwing away some of the data. Some "automatic" computer programs do this because they were created to deal with "normal" images rather than astronomical ones. Likewise, data can be lost through human error. The image above shows the Whirlpool Galaxy after bad processing. In this case, the nucleus of the galaxy is burned up and the delicate detail of its arms and the faint background galaxies are all gone. Where did the detail go?

What happened to our example is called "clipping," an apt name because we clipped off the data on both the bright and dark ends of our image. Faint things became pure black; bright things with still some detail became pure white. In essence, the dynamic range was reduced.

Photoshop to the rescue

Adobe *Photoshop* is a terrific image-processing program that I recommend highly. Let's open the example image of M51 with *Photoshop*, this time being careful not to lose the detail at the ends of the dynamic range. To do that, bring the image into *Photoshop* in full 16-bit mode.

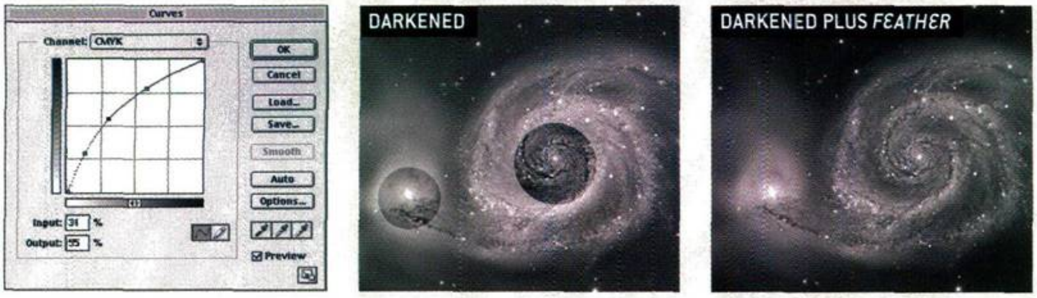
At first, the image looks dark. I use the *curves* function to anchor down the end points of the dynamic range and start "stretching" the data in the middle. Think of this as a rubber band. You can pull it this way and that, but the ends remain the same. Our goal is to lighten the tonal values in the middle. After a few iterations of adjusting the curves, a better image begins to appear. Notice that the ends of our data have not been clipped. Without getting too technical, we can adjust the curves until we have good shadow detail and a bright nucleus that is not washed out. So far so good. Our shadow detail shows

Continued on page 88

THE HORSEHEAD NEBULA (BARNARD 33) in Orion was imaged with an SBIG ST-10E CCD camera attached to a 6-inch Astro-Physics refractor at f/7. TONY HALLAS AND BILL WILLIAMS

SPIRAL GALAXY NGC 7331 was captured during a 150-minute exposure made by the author from Foresthill, California.

THE VEIL NEBULA was a 12-minute exposure through a 4-inch William Yang refractor at f/8.



Channel: CMYK
Input: 31 %
Output: 55 %

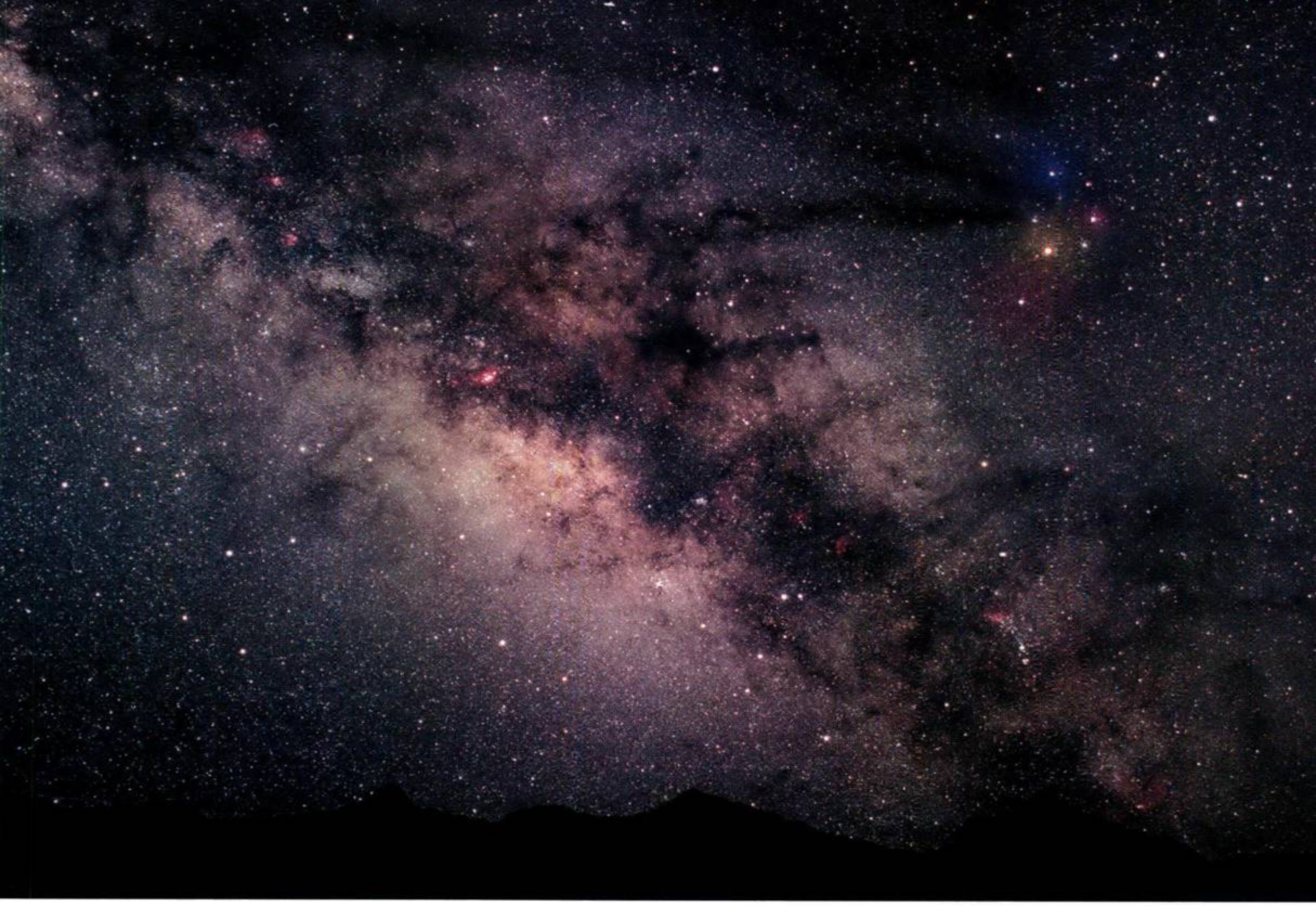
***PHOTOSHOP*'S "CURVES" FUNCTION** (left) allows you to adjust either the overall image or any of the color channels. Overexposed areas of the image, also known as burned-out regions, look better when darkened, but that creates an unattractive circle of unequal illumination (center). This circle is eliminated by the process of feathering (right).

much more information. Now, can we bring out more detail in the bright nucleus?

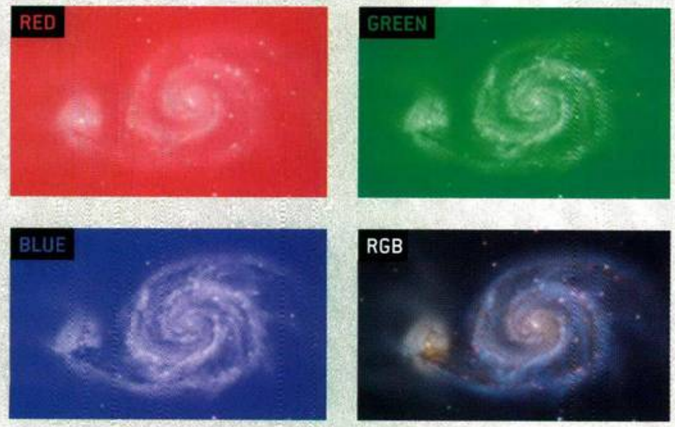
Let's select the area we want to darken. Using *curves* again, we'll bring the tonal values down inside the circle. More detail is revealed, but the circle is too obvious. Let's *feather* the selection so the darkening effect is gradual. Now the boundary is invisible, and the nucleus is darker. These adjustments reveal details from the dim depths of space all the way to the bright nucleus of the galaxy. 16-bit data and high dynamic range that were not clipped made this possible. Ultimately — with enough data — one can bring up the shadow detail while holding the galaxy at a normal density so that myriad background galaxies appear. In one image of the Whirlpool Galaxy (not shown), I used this technique to remove the brightest stars. Most of the barely visible "fuzzies" left in the image were galaxies, the dimmest registering at a faint 24th magnitude!

Dealing with color

Finally, there is color, and the same concepts apply — threefold. CCD cameras only record in black and white, but if we define red, green, and blue channels with filters, we can create images in each of those colors. Recombining the three color images gives us a true-color, "RGB" image. This is commonly called the "tri-color technique." In practice, it's the same as using black-and-white film with the added benefit of a CCD camera's sensitivity.



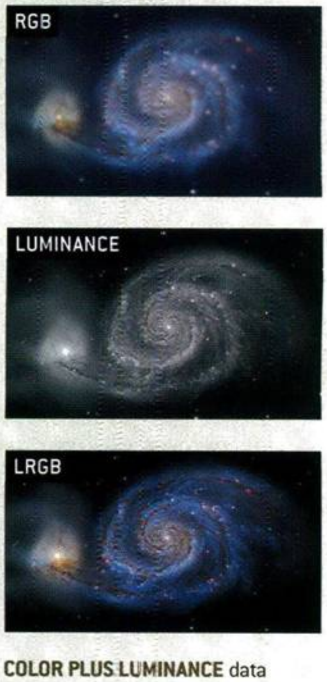
A GREAT EXAMPLE of using digital processing to bring out the best of a film image is this picture of the summer Milky Way. The original exposure was through a 35mm Nikon lens using Kodak RG 200 film. The negative was scanned and the picture was brought to life with the help of Adobe *Photoshop*.



THE TRI-COLOR TECHNIQUE involves taking three separate images through a CCD camera, one each through red, green, and blue filters. Combining the images with software gives a full color (RGB) image.

We can improve our image with one more step. Wouldn't it be great if we could sharpen a single black-and-white image, making it the "detail" part, and combine it with the RGB color information to create a "super image" with the best qualities of both? We can! An additional frame called "luminance," or "L," can be taken and combined with the color data to produce a fantastic "LRGB" image.

I have touched upon some important concepts to help you achieve photo-realistic images using a digital source. Other CCD processing techniques exist, and some offer greater technical depth. The sky truly is the limit when it comes to CCD imaging. A solid foundation rooted in the basic concept of preserving all data in the final image is a prerequisite for achieving the best results. Indeed, new CCD technology allows you to venture far beyond the boundaries imposed by film.



COLOR PLUS LUMINANCE data equals a stunning LRGB image.

TELESCOPE REVIEW

These impressive binoculars provide brilliant, wide-field views of celestial objects.

/// BY PHIL HARRINGTON

JMI's RB-66 binoscope

Mention binoculars, and most of us envision a pair of small prismatic refracting telescopes joined together by a central spine. Their small size and light weight make binoculars perfect for an impromptu viewing session — whether a distant scene, a bird in flight, or a look at the night sky. ☾ Of course, not all binoculars are small and light. Some are large and heavy. Despite their differences in size, however, all binoculars have the same basic design. Until now.

A new concept

Late in 2002, Jim's Mobile, Inc., (JMI) introduced an innovative product called the RB-66 binoscope. The "RB" stands for "Reverse Binoculars," something the amateur market hadn't seen. The RB-66 is, in effect, two 6-inch f/5 Newtonian reflectors with a protective "clamshell" of molded plastic surrounding the entire assembly.

The RB-66 comes with an alt-azimuth mount that attaches to a Celestron tripod. Accessories include two 20mm matched Plössl eyepieces (any two identical eyepieces will work), two Celestron 1¼" mirror star diagonals, and Celestron's Star Pointer red dot unity finder. JMI's own NGC micro-Max digital setting circles (with a database of 245 objects) is an optional accessory. The mount is predrilled to accept the NGC micro-Max and its encoders. A highly recommended accessory is a foam-lined, wheeled carrying case. The case helps when the RB-66 must be moved or shipped.

Design

Light enters the two tubes of the RB-66, reflects from the primary to the secondary mirrors, and exits through focusers that face each other. A pair of star diagonals then turns the light path 90°, toward the front of the instrument where the observer views from a seated position. The tubes are separated by about 10 inches, so the observer's head won't block the view.

One problem JMI overcame was how to focus the image. Conventional focusers move in and out, but that would never do for the RB-66 because the distance between eyepieces (called the interocular distance) changes every time they're focused. This distance has to be adjustable for each observer, but once set, it needs to remain fixed.

To solve the dilemma, JMI modified and motorized their RCF-mini focuser to slide parallel to the tubes. Each secondary mirror holder is permanently attached to the focuser to move with the eyepiece. The focusers are independently adjusted by pushing two sets of buttons on the RB-66's control panel, which is located between the tubes.

Interocular distance also is adjusted electrically with a rocker switch. The controls' motions are smooth, although focuser travel is a little fast. I would have preferred a two-speed control to make critical focusing easier. The folding control panel also has a pair of foam-covered, motorcycle-style handles for pointing the binoculars.

Power

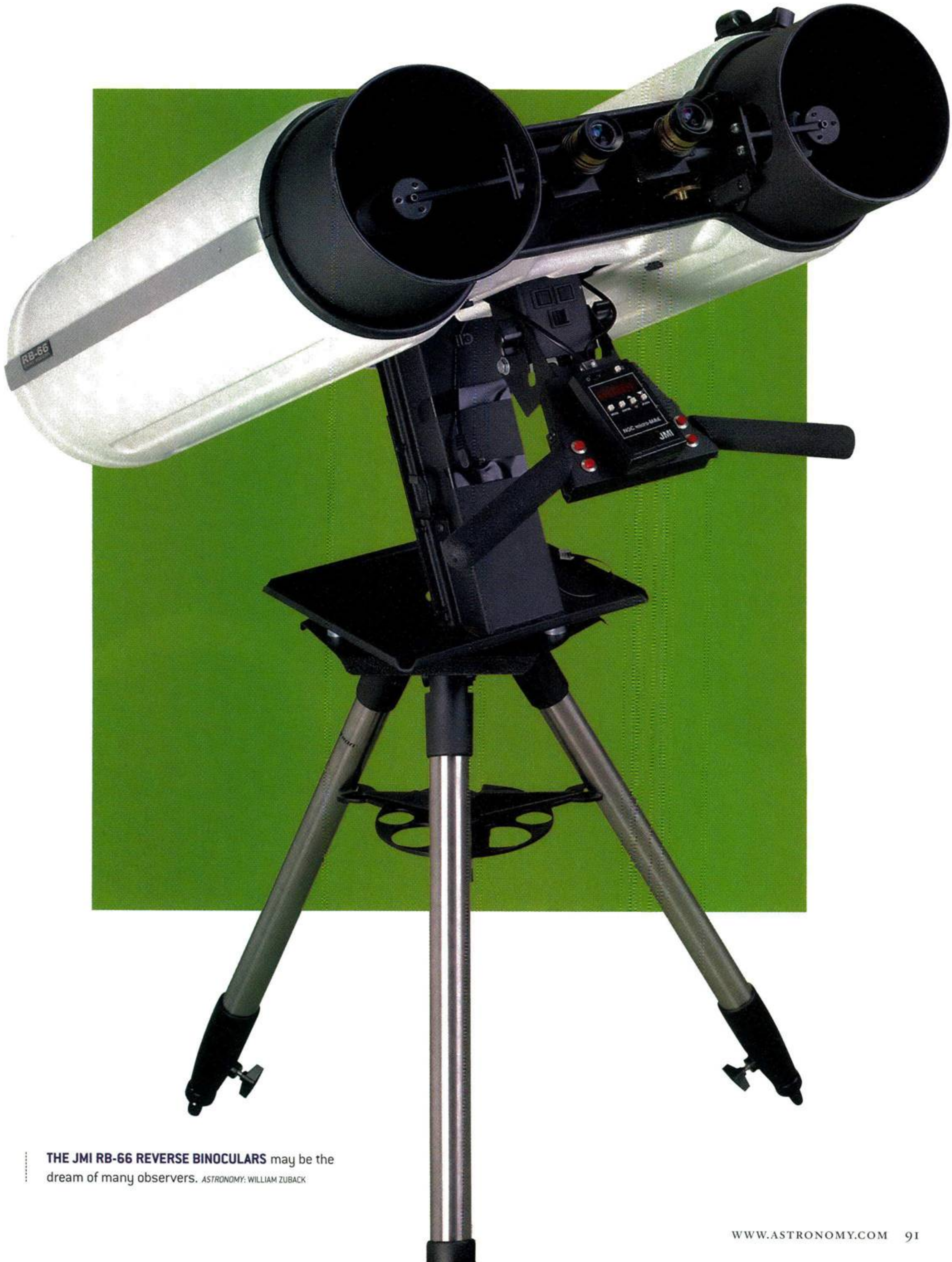
A 6-volt, 4.5-amp-hour rechargeable battery hidden inside the pier supplies power for the RB-66's motorized focusers and adjustment motors. Just insert the plug into the connector mounted on the pier, and the system is ready to go. A charger that comes with the telescope plugs into a standard wall socket to recharge the battery when needed. This battery really holds a charge. Although I used the telescope extensively for more than a month, I never had to recharge the battery.

Setup

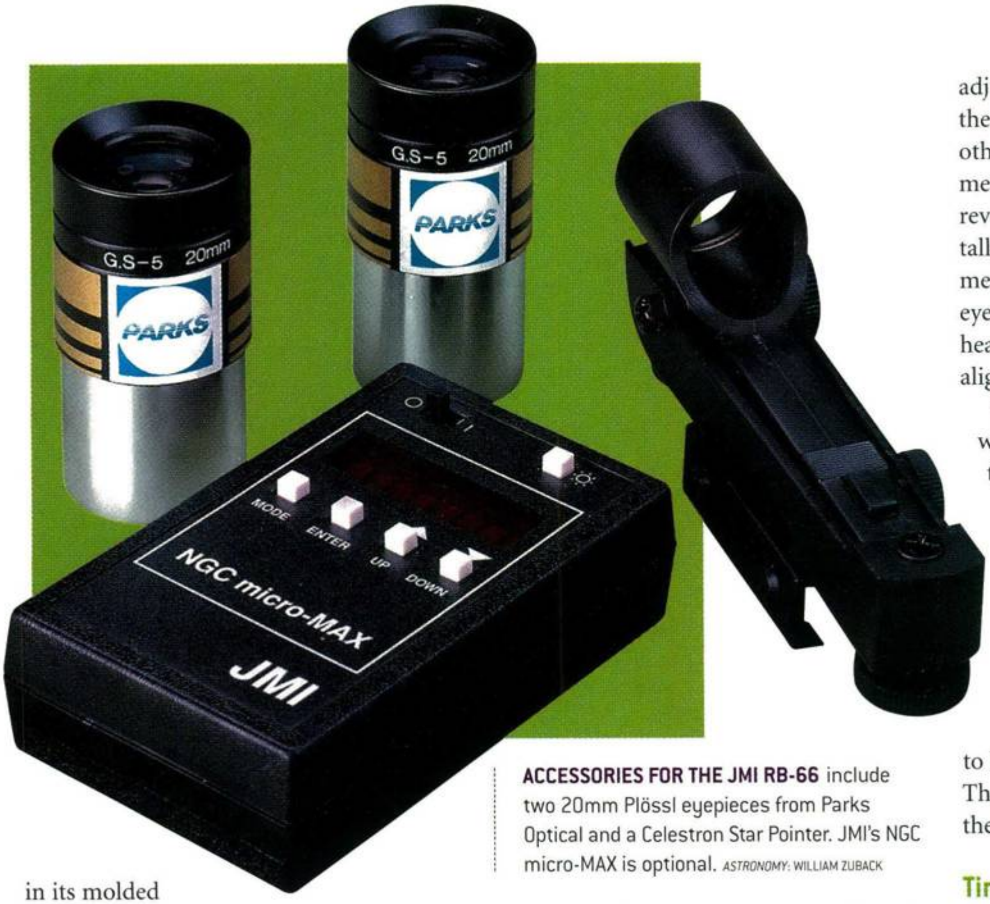
The RB-66 arrived from the factory in two boxes, one holding the binocular telescope

THE CARRYING CASE FOR THE JMI RB-66, foam-lined and equipped with wheels, makes transporting the unit easy while offering solid protection. *ASTRONOMY*: WILLIAM ZUBACK

Phil Harrington *is the author of the new observing guidebook* Star Watch.



THE JMI RB-66 REVERSE BINOCULARS may be the dream of many observers. *ASTRONOMY*: WILLIAM ZUBACK



ACCESSORIES FOR THE JMI RB-66 include two 20mm Plössl eyepieces from Parks Optical and a Celestron Star Pointer. JMI's NGC micro-MAX is optional. *ASTRONOMY*: WILLIAM ZUBACK

in its molded carrying case, and a second containing the tripod. The RB-66 comes from the factory fully assembled. Just remove a shipping brace and attach the finder to the protective cover.

To set up the RB-66, first open the tripod and adjust the length of its legs. At this point, attach the tripod's leg spreader to strengthen the assembly. Before lifting the binocular unit out of its case and onto the tripod, tighten the vertical position lock to hold the binoculars rigidly to the alt-azimuth mounting. This way, the mount won't flop around when the instrument is lifted by the top-mounted handle. Place the mounting base on top of the tripod and bolt the two together using the three captive thumbscrews.

Although this sounds simple, it takes some getting used to. I had difficulty positioning the instrument's base exactly over the tripod's three mating holes, especially at night. An alignment pin or some other reference key machined into the base of the RB-66 would have made the whole process much easier.

Once the telescope and tripod are bolted together, they can be carried as a unit to your favorite viewing spot by lifting the carrying handle with one hand and the base with the other. But be forewarned: The RB-66 is no lightweight. The inseparable binocular telescope and alt-azimuth mount weigh nearly fifty pounds, and the tripod adds another ten. Because of its weight and ungainly shape, the assembled system may be difficult for some observers to move alone.

Alignment

Like using any reflecting telescope with a fast focal ratio, the first thing to do when setting up for an observing session is to check the system's optical collimation. The test instrument arrived with both sides out of collimation, but gaining access to the three adjustment screws behind each mirror was easy: I simply removed the instrument's carrying handle and pulled away the cover's top half.

Once collimation is complete, both telescopes must be aimed parallel to one another, an easily accomplished task. Aim the RB-66 at a known object such as the Moon or a bright star to check and adjust this. Center the target in one of the eyepieces and then look through both eyepieces. By flipping the two rocker switches back and forth on the control panel, a pair of electric motors moves the telescope on the observer's right horizontally and the telescope on the left vertically. As the instructions advise, move the horizontal adjustment first, until the two images of the target lie directly above and below each other. Then, use the vertical motor to merge the two into one. If the process is reversed and the target is aligned horizontally first, the observer's eyes will try to merge the images by crossing. "Crossed eyes" frequently cause eye fatigue and headaches when an observer is using misaligned binoculars, regardless of their size.

The alignment process gets even easier with practice, but I would have preferred the alignment motors to have both low- and high-speed settings, because I often overshot the exact point where the images merged. It's also easy to confuse the two identical switches that control the alignment motions, since both rock left to right. A better design would have been for the left-hand (vertical) switch to be mounted perpendicular to the other. That way, both switches would toggle in the direction they move the telescopes.

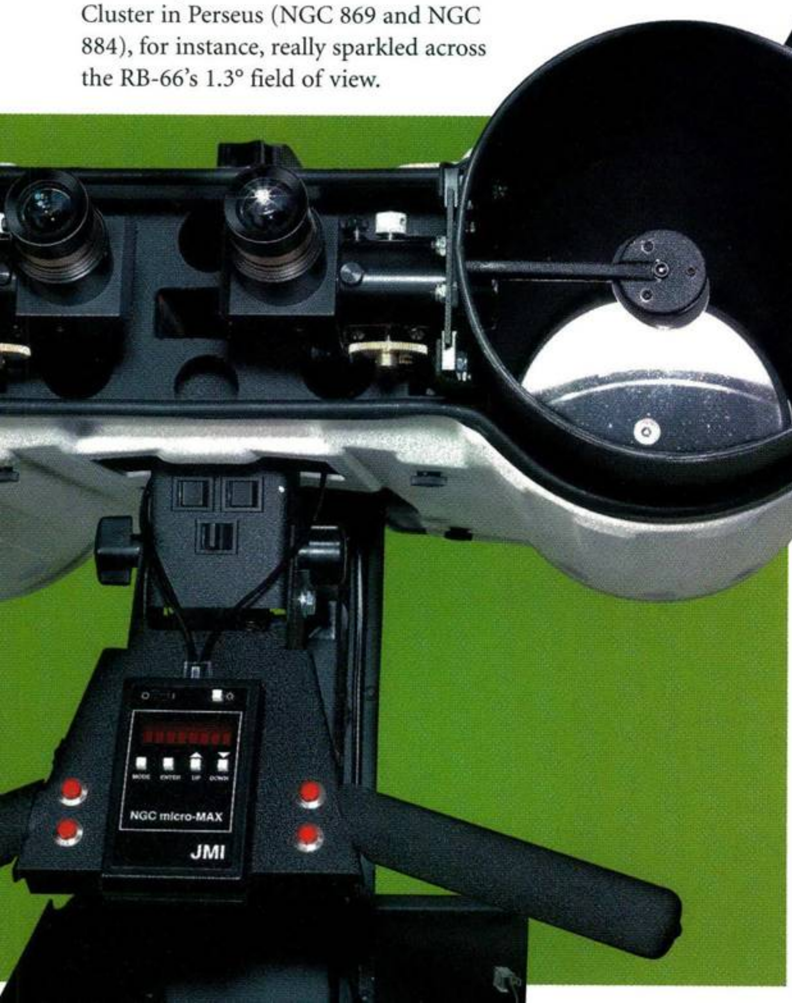
Time to observe

As luck would have it, the sky was clear the first night after I received the RB-66, so I

TWO 6-INCH REFLECTING TELESCOPES stare over your shoulders while you are observing with the JMI RB-66. *ASTRONOMY*: WILLIAM ZUBACK eagerly walked it outside and set it up for a look around. I didn't bother waiting for complete darkness before aiming at my *first target*, the waxing crescent Moon. My first impression? "Wow!" The sunlit part of the lunar surface was sharp with excellent contrast, but the portion lit only by earthshine really impressed me. Binoculars seem to show that area better than telescopes anyway, but the RB-66 outdid any I have used. The view of the still-dark maria and major craters along with the illuminated crescent created a surreal, faux 3-D effect that was quite striking.

After twilight faded, I turned the instrument toward Jupiter. The supplied 20mm eyepieces produce only 38x — not enough to see great detail but enough to show all four Galilean moons, the planet's north and south equatorial belts, and many other features.

While there may be telescopes better suited for planetary observing, the RB-66 is in a league of its own when it comes to large deep-sky objects like the Orion Nebula (M42), the Lagoon Nebula (M8), and the Andromeda Galaxy (M31). I was particularly impressed with the RB-66's view of open star clusters. The Double Cluster in Perseus (NGC 869 and NGC 884), for instance, really sparkled across the RB-66's 1.3° field of view.



I also was struck by how much image contrast improved when using both eyes. Whether it was the faint, luminous bridge connecting the Whirlpool Galaxy (M51) to its irregular galactic neighbor NGC 5198, or the gentle rifts of the Lagoon Nebula, object contrast and brightness were enhanced when I used both eyes as compared to viewing through just one side of the binoscope. There was also a slight improvement in limiting magnitude (the faintest stars that can be seen), typically between 0.1 and 0.2 magnitude.

Optics and mechanics

To star-test the RB-66, I checked each optical assembly using a 10mm Tele Vue Radian eyepiece and 2.5x Powermate, which produced 193x. Both telescopes had excellent optics that produced textbook diffraction patterns, giving little indication of optical aberrations. It's critical for a binocular telescope to have identical sets of optics because even a slight difference in focal length between the two will create viewing problems. As far as my visual tests could determine, both 6-inch telescopes were equal in every way.

Summary

Few binoculars can compare to the RB-66. The best known, comparable system in the 6-inch size range is the Fujinon 25x150 MT-SX binoculars, which retails for about $6,000 (mounting extra). The higher cost and fixed eyepieces of the Fujinon binoculars are distinct disadvantages, but setup time is reduced — there's no need to collimate optics or align tube assemblies.

If you're looking for breathtaking low- and medium-power views of star fields, nebulae, star clusters, and the Moon, give the RB-66 from JMI serious consideration. For observers who appreciate the wonderful views seen only through a true binocular telescope, the RB-66 is a real bargain.

/// RB-66 SPECIFICATIONS

Type: Binocular Newtonian reflectors
Optical system: 6-inch f/5 primary mirrors, 1.6-inch secondary mirrors
Interocular spacing: Variable from 2 inches to 3.25 inches
Weight: 49.4 pounds
Height: 29.5" (locked into vertical position)
Width: 24"
Depth: 10.5" (folded)
Tripod weight: 9.6 pounds

Equipment

Standard

- Two 20mm matched Plössl eyepieces
- Two Celestron 1¼" mirror star diagonals
- Celestron Star Pointer red-dot unity finder
- Protective white clamshell cover (available in black by special order)
- Six motors for adjusting interocular spacing, focusing, and optical tube alignment
- Rechargeable battery and charger

Price: $2,995

Optional

- NGC micro-MAX computer, $399
- Carrying case with wheels and handles, $399.95

Contact information:
Jim's Mobile, Inc.
810 Quail Street, Unit E
Lakewood, CO 80215
[t] 303.233.5353; 800.247.0304
[w] www.jimsmobile.com

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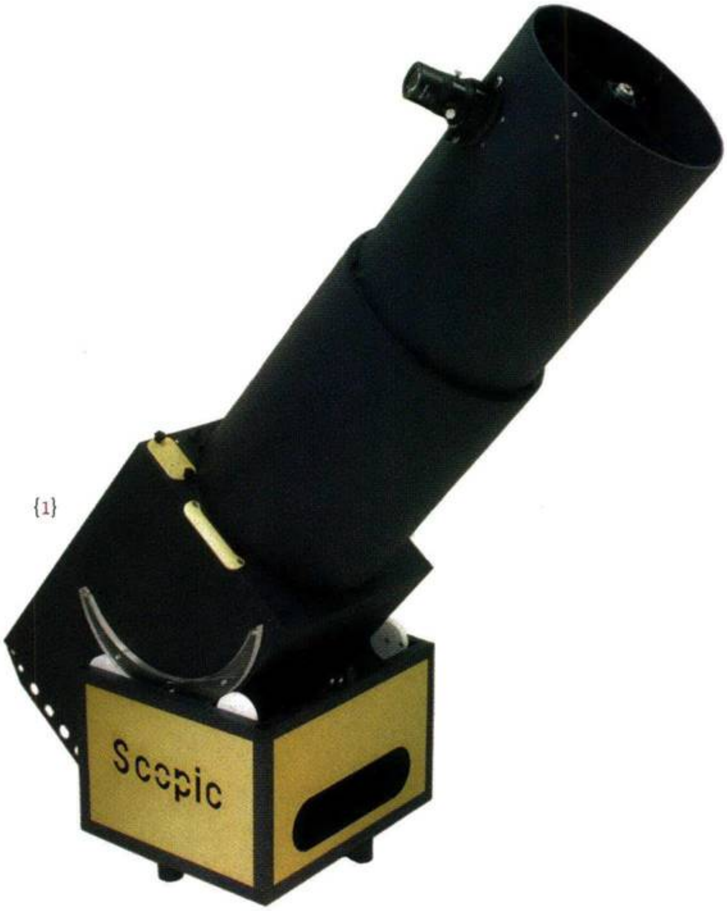

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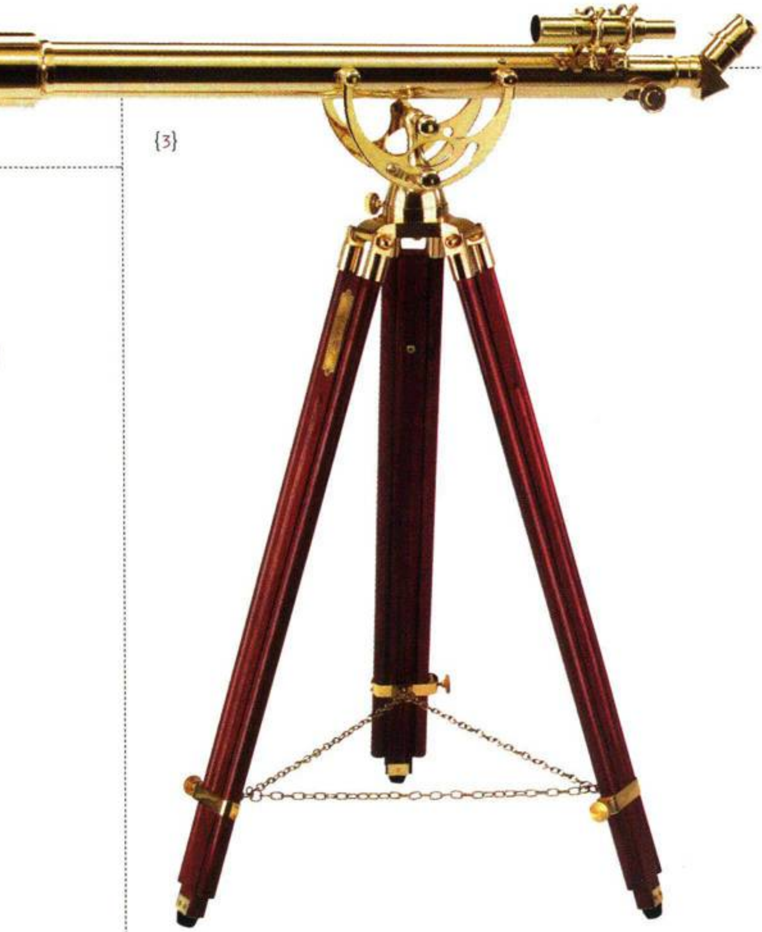

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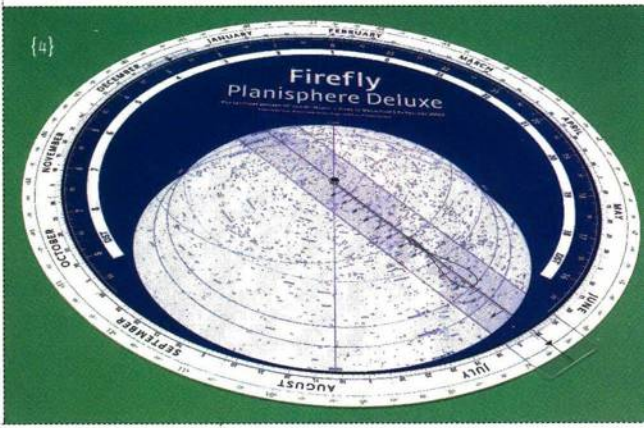

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3. Aristocrat 60mm brass refractor
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$799; Orion Telescopes & Binoculars
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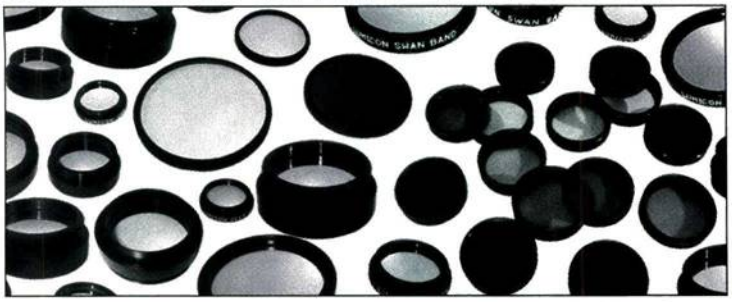

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The Lumicon UV Dust Seal keeps dust and insects out of your telescope. The seal mounts on the back of your SCT and accepts all attachments. It is an ultraviolet filter that passes all visible wavelengths of light with minimal absorption, no aberration, and no noticeable internal reflections. Fully Multi-Coated.

5-9.25" SCT / Mak – $39.95 • Meade 10/12/14" – $89.95 • Celestron 11/14" – $89.95

LUMICON COMET BAND FILTER

Lumicon's narrow visible bandpass (25nm) Comet Band Filter isolates the 501nm OIII and the Cyanogen lines at 511nm and 514nm. The high contrast gain of the filter reveals the delicate ionized tail of gaseous comets, allowing you to see their full extent. The Comet Band Filter also helps you to better distinguish gaseous comets from dusty comets which show little contrast gain. For dusty comets, use the **Lumicon Deep Sky Filter**.

Howard Brewington, famed comet discoverer says: "I discovered Comet Aarseth-Brewington, 1989a1, using the Lumicon Comet Band Filter. The filter doubled the contrast, making the comet very easy to spot." Be the person to discover the next "Comet of the Century" using the Lumicon Comet Band Filter.

1.25" – $99.95 • Brandon 1.25" – $99.95 • 48mm – $199.95 • Visual Back – $199.95

SOLAR PROMINENCE FILTERS

The 1.5 Ang. Lumicon Solar Prominence Filter system lets you see the awe-inspiring solar prominences jutting from the edge of the sun. Sunspots and bright filaments can also be seen on the sun's surface. The filter has a 2" barrel for insertion into 2" focusers, and can be easily adapted for 1.25". It also has camera T-threads and a viewing adapter for 1.25" eyepieces.

Solar Prominence Filter $699.95 • 58mm Energy Rejection Prefilter – $169.95 • 77mm Energy Rejection Prefilter – $199.95

Off-Axis Mask for 8" SCT – $69.95 • Off-Axis Mask for Meade 10" – $89.95 • Off-Axis Mask for C11 – $99.95 • Off-Axis Mask for 12" LX200 – $99.95 • Off-Axis Mask for C14 – $119.95 • Off-Axis Mask for M14 – $119.95 • Off-Axis Mask for 16" LX200 – $129.95

MULTIPLE FILTER SELECTOR

The Lumicon 1.25" Multiple Filter Selector lets you switch instantly back and forth between your Lumicon 1.25" filters without having to constantly thread and unthread them from your eyepieces. You may leave one of the 5 slots open to compare filtered and unfiltered views. – $129.95

EASY GUIDERS

All of Lumicon's famous off-axis guiders feature Lumicon's patented radial and rotational off-axis adjustments – combined with a large off-axis pick-off prism, making bright guide star selection a breeze.

CASSEGRAIN EASY GUIDER FOR 7" TO 9.25" SCTs

The Lumicon Cassegrain Easy Guider allows off-axis guiding with your Cassegrain telescope while reducing the f-ratio from f/10 to f/6.3 using a large, fully-coated focal reducing lens. The faster f-ratio, combined with the ease of finding and guiding on bright guide stars, minimizes guiding error, making for successful astrophotos. Threaded for 48mm filters. Specify camera type when ordering.

Celestron 5 – $249.95 • 7" Mak – $249.95 • 8" SCTs – $249.95 • Celestron 9.25" – $249.95

GIANT EASY GUIDER FOR 10" TO 16" SCTs

The Lumicon Giant Easy-Guider is a powerful photo/visual tool, utilizing an 80mm multicoated compression lens to reduce your Schmidt-Cassegrain's f/10 optics to f/6.3 for wide-angle photography. Ideal for 35mm and 120 format film with 100% edge-to-edge illumination and pinpoint star images. All other off-axis guiders have prisms and focal reducing lenses a fraction the size of the Lumicon Giant Easy Guider's. Threaded for all Lumicon 48mm filters. Specify camera type when ordering.

10", 12", 14" and 16" Meade – $399.95 (Meade 16" LX200 requires adapter - $169.95) • 11" and 14" Celestron – $399.95

NEWTONIAN AND REFRACTOR EASY GUIDER

The Lumicon Newtonian and Refractor Easy Guiders allow off-axis guiding directly through the main telescope, thus preventing differential flexure between telescope and guide scope that can ruin your astrophotos. Low-profile design installs in seconds into 1.25" and 2" focusers. Threaded for 1.25" and 48mm filters. Specify camera type when ordering.

1.25" and 2" Newtonian – $189.95 • 1.25" and 2" Refractor – $189.95

LUMICON EASY GUIDER ACCESSORIES

- Newtonian Easy-Guider Focal Reducer Lens in Cell – $79.95
- Giant Easy-Guider Focal Reducer Lens in Cell – $199.95
- Giant Easy-Guider - No Lens – $319.95
- Cassegrain Easy-Guider - No Lens – $219.95

LUMICON 3X RELAY DIAGONAL FOR USE WITH EASY GUIDERS

Lumicon Relay Diagonal's 3x Barlow lens increases the guiding magnification in the off-axis portion of your Lumicon Easy-Guider, increasing off-axis guiding ease and precision. – $99.95

HYPER KITS

LUMICON FILM HYPERSENSITIZATION KITS

Film hypersensitization with a Lumicon Hyper-Kit super-dries your film's emulsion using nitrogen and hydrogen (Lumicon's Forming Gas: 8% prepurified hydrogen, 92% prep. nitrogen, removing ALL water vapor and oxygen molecules, thus thermally stabilizing the film's emulsion. The process also 'soaks' the emulsion with hydrogen, thus sensitizing the silver halide crystals, making them more sensitive to faint light. The combined effect reduces reciprocity failure of the film, allowing it to remain sensitive to light well beyond an hour instead of only a few minutes. Hypered film is a MUST for anyone who is serious about taking deep-sky photographs.

LUMICON MODEL 300 FILM HYPERSENSITIZATION KIT FOR 35MM AND 120 FILM

For simplest hypering with film still in its metal cassette, the Model 300 Hyper-Kit is easy in use and safe for your film. Operates with Lumicon's Forming gas at 30° C. Hypers film in two to five days.

Chamber Only – $249.95 • Film Hyper Kit – $375.95 • Hyper Kit O-Ring Set – $9.95

LUMICON MODEL 600 FILM HYPERSENSITIZATION KIT FOR 35MM AND 120 FILM

The versatile Lumicon Model 600 Hyper-Kit is capable of hypering film either while still in its metal cassette at 30° C, or more quickly with highest saturation on the open reel at 50° C. Super-dries and sensitizes the film's emulsion with Lumicon's Forming Gas.

Chamber Only – $299.95 • Film Hyper Kit – $475.95 • Hyper Kit O-Ring Set – $9.95 • Hyper Kit Hand Vacuum Pump – $39.95 • Hyper Kit Vacuum Pump Handle – $9.95

LUMICON MODEL 1200 FILM HYPERSENSITIZATION KIT FOR 35MM, 120, AND 4x5 FILM

Large-capacity Lumicon Model 1200 Hyper-Kit accepts 4x5 film. Kit is capable of hypering film in just 12-to-20 hours with highest saturation. Super-dries and sensitizes the film's emulsion with Lumicon's Forming Gas at either 30° or 50° Centigrade for simple or advanced modes of operation.

Chamber Only – $379.95 • Film Hyper Kit – $751.95 • 4x5 Plate Holders – $99.95 • Hyper Kit O-Ring Set – $9.95

HYPER KIT ACCESSORIES

- 4x5 Sheet Film holder – $99.95
- 35L Cylinder of Forming Gas – $145.95
- 30° C Temperature Sensor Probe – $99.95
- 50° C Temperature Sensor Probe – $99.95
- Temperature Controller – $139.95 • Electric Vacuum Pump – $349.95 • 220 V option on Vacuum Pump – $44.95 • 220V/110V Converter – $29.95 • Vac/Pressure Hose with Clamp – $9.95

ASTROPHOTOGRAPHY FILM

HYPERED FILMS

Use Lumicon Hypersensitized Film to take stunning astro photographs. Allows you to expose film on your favorite deep sky object far longer, with no fog buildup, than does non-hypersensitized film.

Fuji G800 – $19.95 • Fuji RD100 – $14.95 • TP2415 B&W – $19.95 • TP6415, 120 – $19.95 • Kodak P1600 – $24.95 • Kodak PPF400 – $19.95 • Kodak PPF400, 120 – $19.95

NON-HYPERED FILM

Lumicon's high-contrast, extremely fine-grained film. High quality for medium-format astrophotography.

TP2415, Bulk 150' Roll – $79.95 • TP2415, Normal 36 exposure – $11.95 • TP4415, 4x5" Normal 25 Sheets – $49.95 • SO-279 Vericolor Slide Film – $14.95 • Kodak 6415, Normal Film – $9.95 • Fuji G800, Normal Film – $9.95 • PPF400, 120, Normal Film – $11.95 • PPF400, 120, Normal Film - 5 pack – $49.95 • Kodak P1600, Normal Film – $19.95 • Fuji Sensia RD100, Normal Film – $9.95

FILM DEVELOPING MATERIALS

- Film Changing Bag – $ 16.95
- Kodak D19 B&W Developer – $ 19.95
- Patterson film developing tank – $19.95

DIAGONALS

ENHANCED ALUMINUM STAR DIAGONALS

The Lumicon Enhanced Aluminum Star Diagonal reflects 96 to 97 percent of the light from the telescope's primary optics into your eyepiece. Its single 1/10 wave precision-polished surface is superior to the three surfaces of prism *diagonals, and its enh*anced coating is more durable than a standard aluminum coating. Lumicon collimates each star diagonal using a double-pass collimator, ensuring that the light reflected from the diagonal is perfectly perpendicular to the telescope's optical axis. 1.25" – $99.95 • 2" – $189.95 includes 1.25" adapter.

LUMIBRITE STAR DIAGONAL

The Lumicon Lumi-Brite Dielectric-Coated Diagonal reflects >98 percent of the light from the telescope's primary optics into your eyepiece. Not only is the Dielectric Coating more durable than a standard aluminum coating, it is also smoother, resulting in higher image contrast. 1.25" – $149.95 • 2" – $239.95 includes 1.25" adapter

SKY VECTOR

The Lumicon Sky Vector is a state-of-the-art digital setting circle system, providing virtually any astronomical telescope, whether equatorial or altazimuth, with a continuous, real-time digital readout of right ascension and declination coordinates. With the Sky Vector, you will be able to find objects even faster than with most fully computer-driven telescopes. Its alphanumeric display uses a simple, easy-to-read scrolling text format. There is no need to polar align or to enter Latitude, Longitude, Date, Altitude, and Sidereal time – just initialize on one or two stars and you're ready to go!

SKY VECTOR 1

The Lumicon Sky Vector 1 features: One- or two-star initialization; 4000-step encoders for high-resolution accuracy (0.09 deg.); Digital Right Ascension coordinate readout to 1 minute; Digital Declination readout to 10 arc-minutes; Guide mode for guiding you to the selected object in current memory; Database containing over 220 of the finest objects in the sky, including the popular "Messier Catalog."

Complete Set – $349.95 • Kit only – $269.95

LUMICON NGC SKY VECTOR

The Lumicon NGC Sky Vector has all the features of the Sky Vector 1, plus a large 12,000-object database, higher resolution display modes, IDENTIFY mode, and current constellation and chart number displays - all on a 16-digit red LED display. It can be integrated with a personal computer for display of celestial object coordinates.

Complete Set – $489.95 • Kit only – $419.95 • Serial Cable – $29.95

SKY VECTOR UPGRADES

- Upgrade 3.65 Chip Set for NGC Sky Vector. – $59.95
- 8192-Step Encoder Set. Can be purchased separately or in place of the standard 4000 step encoders. – $29.95

LUMICON SKY VECTOR HARDWARE PACKAGES

Lumicon Sky Vector Hardware Package for Meade and Celestron SCTs includes: declination encoder bracket, right ascension encoder holder, encoder shaft holders, Allen wrench, and instructions.

Lumicon Sky Vector Hardware Package for Dobsonian telescopes includes: brass azimuth bolt, stainless steel azimuth encoder bracket, aluminum altitude-encoder-shaft holder, stainless steel altitude encoder bracket, 10 wood screws, Allen wrench, and instructions.

C5+ – $79.95 • C8 – $69.95 • Celestar 8 – $79.95 • Celestar 8 Dlx – $79.95 • G8/G11 – $349.95 • Ultima 8 – $79.95 • Ultima 11 – $99.95 • C11 – $79.95 • C14 – $129.95 • Meade 2080 – $69.95 • 2120 – $79.95 • 8" Dob – $69.95 • 10" Dob – $69.95 • 12/13" Dob – $79.95 • 16/17" Dob – $89.95 • CI700 – $299.95

RICHFIELD VIEWERS

RICHFIELD VIEWER FOR 7" TO 9.25" SCTs

The Lumicon Richfield Viewer takes your Schmidt-Cassegrain's f/10 optics and reduces them to f/6.3 for beautiful wide-field views. Its fully-coated 50mm diameter focal reducing lens has a larger clear aperture and less coma than higher-priced focal reducers on the market, providing superb unvignetted views. Barrel accepts 2" star diagonals. Comes with an aluminum 2"- 1.25" eyepiece reducer, threaded for 48mm filters. – $99.95

RICHFIELD VIEWER, THREADED FOR 7" TO 9.25" SCTs

Threads directly into telescope. – $99.95

RICHFIELD VIEWER, SLIDE-ON, FOR 7" TO 9.25" SCTs

For attachment onto SCTs that have the Lumicon Easy-Guider threaded attachment ring in place. Slides over attachment ring. – $99.95

GIANT RICH-FIELD VIEWERS

LUMICON GIANT RICH-FIELD VIEWER FOR LARGE SCTs

Takes your large Schmidt-Cassegrain f/10 optics and reduces them to f/6.5 for the widest possible views of large galaxies like M31, M33 and NGC 253, and pairs of galaxies like M81 and M82. Moving the 80mm diameter focal reducing lens to the forward position in the Rich-Field Viewer body yields an even wider field. Comes with a 2"- 1.25" eyepiece reducer, threaded for 48mm filters.

10" SCTs – $279.95 • Celestron 11" – $279.95 • 12" SCTs – $279.95

LUMICON 2.5X CCD COMPRESSOR

This cost-effective, fully-coated lens widens the telescope field and yields pinpoint star images for small to medium-size CCD cameras. Has male threads for standard 1.25" eyepieces or camera-type barrels. – $129.95

LUMICON 48MM COMA CORRECTOR FOR NEWTONIAN EASY GUIDER OR 2" EYEPIECE

The Lumicon Coma Corrector lens dramatically reduces coma when used, in particular, with f/3.5 to f/6 Newtonian telescopes. It makes off-axis star images much smaller, thus improving photographic quality and making guiding much easier. Free of all chromatic aberration and fully multicoated to prevent ghost images. Can be used on all 48mm threaded accessories. Neither shrinks nor magnifies the image. – $239.95

LUMICON 1.5x–1.8x MULTIPLIER/FIELD FLATTENER

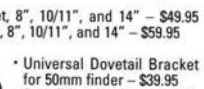
The Lumicon Multiplier / Field Flattener Lens has been custom computer-designed to increase image scale with the flattest field possible for photography and visual use with fast Newtonian Telescopes. This lens is suitable for use with f/3.5 to f/6 systems. Fully multicoated for maximum light transmission. – $259.95

FINDERSCOPE

Lumicon 80mm SuperFinder for Right-Angle viewing. This finder telescope actually lets you see many of the deep-sky objects you are looking for, complementing any telescope having 8 or more inches of aperture. It also makes for a wonderful rich-field telescope for beautiful views of the Milky Way. Comes with 25mm, 1.25" cross-hair eyepiece and helical drawtube-type focuser.

50mm RA Finder - Body Only – $79.95 • 50mm RA Finder - Complete – $149.95 • 50mm Straight-Thru Finder - Body Only – $79.95 • 50mm Straight-Thru Finder - Complete – $119.95 • 80mm Right Angle SuperFinder - Body Only – $199.95 • 80mm Right Angle SuperFinder with Tripod Block – $219.95 • 80mm Right Angle SuperFinder - Complete – $299.95 • 80mm Straight-Thru SuperFinder - Body Only – $199.95

FINDERSCOPE BRACKETS



This two-ring finder bracket firmly holds finderscopes to your telescope while allowing precise alignment with the main optical axis. The base is radius-cut to fit snugly against the telescope's main tube, and the dovetail groove makes it easy to install or remove the finderscope from the base. Fastens in brand name SCT telescope mounting holes.

- 50mm Finder Bracket, 8", 10/11", and 14" – $49.95
- 80mm Finder Bracket, 8", 10/11", and 14" – $59.95

- Universal Dovetail Bracket for 50mm finder – $39.95
- 2 traditional universal ring-type brackets for 50mm finder – $19.95

LUMICON 25MM CROSS-HAIR FINDERSCOPE EYEPIECE

This well-made 25mm, 1.25" Kellner single-crosshair finderscope eyepiece is ideally suited for Lumicon's 50mm and 80mm SuperFinders. High contrast and flat field. Non-illuminated. – $69.95

GUIDING EYEPIECE

LUMICON GUIDING EYEPIECE WITH RETICLE ILLUMINATOR

Lumicon's top-quality 12.5mm, 1.25" Orthoscopic eyepiece with focusable dual cross hair for precision guiding. Incorporates new state-of-the-art cordless Reticle Illuminator, featuring rheostatic brightness control and on/off switch.

12.5mm, 1.25" Illuminated Reticle Eyepiece. – $149.95 • Pulseguider Illuminator – $42.95

BINOVIEWER

LUMICON BINOVIEWER

These new high-quality German-made binoviewers employ Grade-A BK 7 crown glass for its precision-polished prisms. Ordinarily, BaK 4 is used as a recourse to improve color correction, but in these binoviewers color correction is so good that we may use the most transparent, homogeneous, bubble-free crown glass available – BK 7. Clear aperture is 22mm. Its straight-through design employs superior roof prisms for image erection. Each prism surface is multicoated for the highest transmission of light and freedom from ghosts. Focuser travel is 20mm. – $699.95

VISUAL AND PHOTOGRAPHIC ACCESSORIES

PHOTOGRAPHIC ADAPTERS

1.25" Prime Focus Adapter – $24.95 • 2" Accessory Adapter for Celestron Classic Refractors – $39.95 • 2" Accessory Adapter for Celestron Fluorite Refractors – $39.95 • .96" Prime Focus Adapter – $19.95 • Basic Camera Adapter 1.25" – $39.95 • Basic Camera Adapter .965" – $39.95 • Adapter to mount Mamiya 645 Camera to 2" – $149.95 • 2" to T-thread adapter – $29.95 • Tele-Extender – $29.95

VISUAL ADAPTERS

1" Thread-in extension tube, 1.25" – $19.95 • 1.25" Focuser to .96" Eyepiece Adapter – $24.95 • 2" Length Drop-in Extension Tube, 1.25" – $19.95 • 4.5" Length Drop-in Extension Tube, 1.25" – $29.95 • 2" Long Thread-in Extension tube, 2" Diameter – $24.95 • 2" Long, 2" Diameter Drop-in Extension Tube – $24.95 • 3" Long, 2" Diameter Drop-in Extension Tube – $24.95 • 2" to 1.25" Reducer – $24.95 • 2" Accessory Adapter for C6 – $39.95 • 2" Accessory Adapter for Schmidt Cassegrains – $39.95 • 2" Accessory Adapter for Celestron Classic Refractors – $39.95 • 2" Accessory Adapter for Celestron Fluorite Refractors – $39.95 • .96" to 1.25" Eyepiece Adapter – $24.95 • f/10 Viewing Adapter for Giant Easy Guider – $89.95 • Adapter for Meade 2" Thread-on diagonal to Cass. Easy Guider – $39.95 • Adapter for Meade 2" Thread-on diagonal to Giant Easy Guider – $49.95 • Adapter to hold 1.25" Eyepiece on T-thread – $29.95 • Adapter to hold 2" eyepiece on T-thread – $49.95

EASY GUIDER ADAPTERS

Adapter to mount Hasselblad Camera to Giant Guider – $449.95 • Adapter to mount Pentax 645 Camera to Giant Guider – $169.95 • Adapter to mount Pentax 6x7 Camera to Giant Guider – $149.95 • 16" LX200 adapter for Giant Guider – $169.95 • Adapter to mount Hasselblad Camera to Cass. Easy Guider – $349.95 • Adapter to mount Pentax 645 Camera to Cass. Easy Guider – $159.95 • Adapter to mount Pentax 6x7 Camera to Cass. Easy Guider – $139.95

STEP RINGS

48mm to 46mm – $11.95 • 48mm to 49mm – $11.95 • 49mm to 48mm – $11.95 • 52mm to 48mm – $11.95 • 52mm to 58mm – $11.95 • 55mm to 48mm – $12.95 • 55mm to 58mm – $12.95 • 58mm to 48mm – $12.95 • 62mm to 58mm – $12.95 • 62mm to 72mm – $14.95 • 67mm to 62mm – $15.95 • 67mm to 72mm – $15.95 • 67mm to 77mm – $15.95 • 72mm to 67mm – $15.95 • 72mm to 77mm – $15.95 • 77mm to 67mm – $15.95 • 77mm to 72mm – $15.95 • 82mm to 77mm – $15.95

LUMICON ADJUSTABLE PIGGYBACK MOUNTS

Lumicon Deluxe Piggyback Mounts allow you to mount the Lumicon SuperFinder, other small telescopes, or cameras having 1/4-20 threaded mounting blocks, onto medium and large telescopes. The Piggyback Mounts are adjustable in altitude and azimuth, thus allowing you to align your optics with the optics of your main telescope. Each of the four available Piggyback mount bases have their own radius cut, allowing a solid flush mount to your telescope's main tube.

6" – $59.95 • 8" SCT – $59.95 • 10/11" SCT – $59.95 • Celestron C14 – $59.95

MISCELLANEOUS ACCESSORIES

HELICAL FOCUSERS

Lumicon Helical Focuser, 1.25" and 2.00" for tube O.D.s 7.5", 9.5", 12.5", 16", and 20". Also flat base or specially for Odyssey.

1.25" Helical Focuser 7.5" – $69.95 • 1.25" Helical Focuser 9.5" – $69.95 • 1.25" Helical Focuser 12.5" – $69.95 • 1.25" Helical Focuser 16" – $69.95 • 1.25" Helical Focuser 20" – $69.95 • 1.25" Helical Focuser, Flat Base – $69.95 • 1.25" Helical Focuser, Odyssey – $69.95 • 2.00" Helical Focuser 7.5" – $99.95 • 2.00" Helical Focuser 9.5" – $99.95 • 2.00" Helical Focuser 12.5" – $99.95 • 2.00" Helical Focuser 16" – $99.95 • 2.00" Helical Focuser 20" – $99.95 • 2.00" Helical Focuser, Flat Base – $99.95 • 2.00" Helical Focuser, Odyssey – $99.95

VINYL DUST COVERS AND PLUGS

1.25" – $6.95 • 1.3" – $6.95 • 1.5" – $6.95 • 2" – $6.95 • 2.1" – $7.95 *(all these prices for a set of four)* • 5.5" – $7.95 • 6.7" – $9.95 • 7.5" – $12.95 • 9.5" – $17.95 • 10.3" – $17.95 • 12.5" – $23.95 • 12.8" – $23.95 • 15" – $35.95 • 15.6" – $36.95 • 16" – $37.95 • 19" – $42.95 • 21" – $45.95 • 1.25" Plastic Dust Plug – $6.95 • 2" Plastic Dust Plug – $8.95 • 3.5" Plastic Dust Plug – $6.95 *(all these prices for each piece).*

LUMICON LUMILITE RED LED FLASHLIGHT

The Lumicon Red LED Flashlight not only provides the proper illumination for star atlases, but also for walking in the dark when held at or below belt level. Has built-in resistor for energy conservation – If you accidentally leave it on when you pack up, its batteries will still be almost as good as new in the morning! Great for astronomers, submariners or pilots who need to preserve their night vision. – $14.95

BARLOWS

Lumicon 2x Barlow 1.25" – $39.95
Lumicon 2x Barlow 1.25" Thread-in – $79.95

12" CAMERA CABLE RELEASE

Self-locking 12" Camera Cable Release for timed exposure. This high-quality vinyl-covered cable release prevents camera shutter vibrations on long exposure photographs – a must for astrophotography. – $19.95

COLLIMATORS

Lumicon Cheshire Collimator for Laser – $39.95

LUMICON 6X CRITICAL FOCUS SCOPE, HAND-HELD

This simple accessory will magnify by 6x stars that are seen through your camera's viewfinder, allowing you to more easily determine when best focus has been achieved. – $19.95

DIAGONAL MIRRORS

1/10 wave flatness, fine-annealed low-expansion Pyrex.

ENHANCED Aluminum >96% reflectivity.

1.33" – $49.95 • 1.55" – $59.95 • 1.83" – $79.95 • 2.60" – $129.95

LUMIBRITE Dielectric Coating >98%

1.33" – $99.95 • 1.83" – $149.95

FILTERS AND LENS CLEANING KIT

Includes: cleaning fluid, lens cleaning tissue, Ultra Brush Dust Remover, blower brush, Q-Tips – $19.95

HOW TO ORDER

You can order online; please visit our website at **www.lumicon.com**, or you can order directly by calling 805/520-0047, 800/420-0255 or fax 805/520-3030; Credit Cards accepted. You can also buy Lumicon products by visiting the showroom of your favorite authorized Lumicon astronomy retailer. All products are subject to shipping and handling charges and sales tax if applicable. Please call us or visit Lumicon's website for more details.

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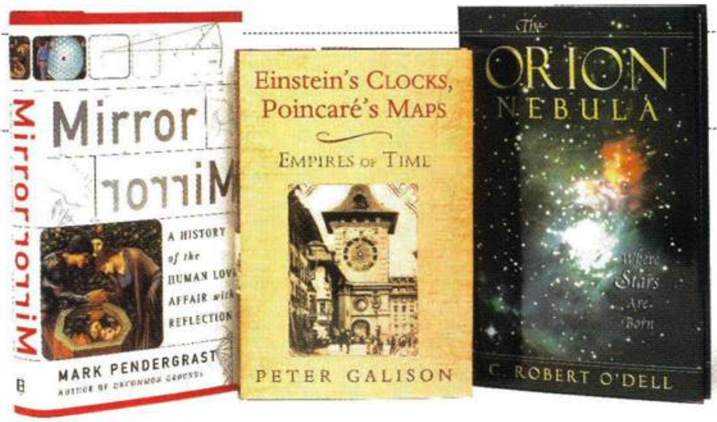
Reflecting on time and space



Mirror Mirror: A History of the Human Love Affair with Reflection

Mark Pendergrast, 404 pages, Basic Books, New York, 2003; ISBN 0–4650–5470–6; hardcover, $27.50.

In the morning, a mirror looks back at us. Hidden in a telescope at night, it helps us view the stars. We gaze into mirrors or avoid them, polish and adjust them, but for the most part, they are little more than backdrop, tool, decoration.

At first glance, these glossy slabs of glass and metal hardly seem substantive enough to fashion a book around. But then Mark Pendergrast begins to reflect on them.

As he did with that other morning mainstay, coffee, in his earlier book *Uncommon Grounds*, the author of *Mirror Mirror: A History of the Human Love Affair with Reflection* adopts an object that we alternately ignore or obsess over as a foil to examine the expanse of human history, psychology, art, and science.

The history of mirrors, ventures Pendergrast, begins with the study of light. Understanding how light bounces (reflects) and bends (refracts) fed the development of telescopes from small, hand-ground lenses in leather tubes to the mammoth 315-inch mirrors of the Very Large Telescope in Chile. His history of mirrors naturally transforms into a history of astronomy.

Pendergrast follows the arc of scientific thought from Plato and his student Aristotle, who speculated on sight and rainbows, to Archimedes, whose ingenious military inventions supposedly included large mirrors capable of focusing enough light to set fire to marauding ships.

The author's gift for storytelling enlivens the time line. In 16th-century England, mirror-gazing blurred the lines between magic and science. Mathematician and optical scientist John Dee became obsessed with the practice of "scrying," the divination of mysteries using mirrors. He fell under the spell of an unscrupulous scryer who ultimately coerced him into a wife-swapping affair with Dee's reluctant bride.

Organist-turned-astronomer William Herschel, who would go on to discover Uranus, ground his own reflectors that soon surpassed those from the United Kingdom's national academy of science, The Royal Society. Once, while trying to pour his biggest mirror ever, Herschel and his assistants had to make a quick getaway when molten copper leaked onto the cool basement floor, causing the flagstones to expand and explode like bombs.

The history of mirror-making for telescopes is fraught with such problems. Exasperatingly, glass bubbles or cracks, cutting tools go berserk, and furnaces collapse, leaving gashes on pristine surfaces. Pendergrast describes innumerable setbacks in the making of masterpieces like Palomar's 200-inch mirror as well as the driven and mercurial personalities, such as George Ellery Hale, behind the projects.

Pendergrast doesn't forget about the specialized mirrors necessary for observing non-visible light, such as the chicken wire-like mesh of radio dishes and the nested, iridium-coated mirrors of the orbiting Chandra X-ray Observatory.

Like the sleight-of-hand mirror-gazers he documents, Pendergrast uses a seamlessly joined collection of facts and anecdotes — sometimes only tenuously mirror-related — to charm the reader. But we are the better for his ruse. Reflected in Pendergrast's exposition on mirrors is a succinct history of the world, scientific thought, and culture itself. — **JESSA FORTE NETTING** *is a science writer in Los Angeles.*

Einstein's Clocks, Poincaré's Maps: Empires of Time

Peter Galison, 389 pages, W. W. Norton & Co., New York, 2003; ISBN 0–3930–2001–0; hardcover, $23.95.

What do train schedules, alarm clocks, submarine telegraph cables, astronomers' charts, a mapping expedition to Ecuador, and a coal mining disaster have to do with mathematical theories of relativity? For readers of *Einstein's Clocks, Poincaré's Maps,* the answer is — everything.

Peter Galison, a professor of physics and science history at Harvard University, has woven together a seemingly disparate collection of physical objects, political preoccupations, and competing philosophies to create a coherent account of the events that led to Albert Einstein's seminal paper on special relativity in 1905. Einstein broke away from the Newtonian idea that space and time are fixed frames of reference. He suggested that the speed of light remains the same for all observers, regardless of their motion relative to the light source, and that all observers moving at a constant speed should observe the same physical laws. This can happen only if measurements of time and length are relative, not absolute.

Galison begins his introduction to the finer points of relativity theory by setting out why clock synchronization was so critical to Einstein. Then, a whirlwind tour of early 20th-century state departments, academic establishments, observatories, and railway stations shows how ideas about the simultaneity of events were gripping Europe and North America.

That broad focus may seem to introduce irrelevancies, but structuring the book around national archives offers an essential perspective. Historians of science often discuss the merits of interpreting ideas in their correct historical context, and Galison labors to show that concept and context cannot be disentangled.

One brickbat concerns style: Galison's attempts to persuade the reader through the use of seductive language occasionally become tiresome. This is especially true in the closing chapter, where an obscure phrase, "critical opalescence," crops up repeatedly, to grating effect.

But while that kind of runaway language distracts, it does not detract from the book's overall quality. Galison meshes even the tiniest details beautifully, and he never "dumbs down" the physics of relativity, explaining the subtle differences between mathematical arguments clearly and precisely. *Einstein's Clocks, Poincaré's Maps* is enormously engaging, entertaining, and informative. — **PAULA GOULD** *is a science writer and a member of the British Society for the History of Science.*

The Orion Nebula: Where Stars Are Born

C. Robert O'Dell, 192 pages, Harvard University Press, Cambridge, Massachusetts, 2003; ISBN 0-6740-1183-X, hardcover, $27.95.

Orion is among the most readily identifiable constellations and home to the colorful Orion Nebula. A mere 1,500 light-years away, the nebula is an easy naked-eye target on a clear, crisp winter night.

The Orion Nebula: Where Stars Are Born takes an in-depth look at this gaseous cocoon glowing with thousands of hot, young stars. Author C. Robert O'Dell, an astrophysicist at Vanderbilt University, is an impeccable and eminently qualified tour guide, having devoted much of the past fifty years to studying the nebula.

Although the book is about a single astronomical object, it touches on the evolution of astronomy over the past four hundred years. O'Dell begins with the nebula's discovery — Nicholas Peiresc, a contemporary of Galileo, first recognized it in 1610. The list of the nebula's intrepid mariners reads like a who's who in astronomy: William Herschel, William Parsons, and Charles Messier each made sketches of Orion; Henry Draper took its first snapshot.

As former chief scientist of the Hubble Space Telescope, O'Dell also gives us an insider's perspective on the famous orbiting observatory. He discusses the physics of light, the lives of stars, and the interaction of matter and radiation — all critical for understanding the Orion Nebula. Then, he paints a 3-D picture of the cloud, detailing its inner workings, age, and likely fate, ruminating on whether there might be planets forming around its stars.

O'Dell deftly weaves his own experiences into this entertaining and informative book, and beautiful photographs, portraits of astronomers, and historic sketches complete the volume. — **JENNIFER BIRRIEL** *teaches physics and astronomy at Morehead State University in Kentucky.*

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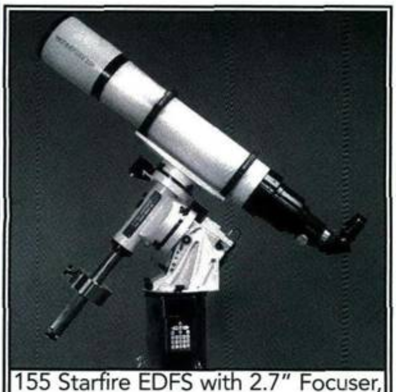

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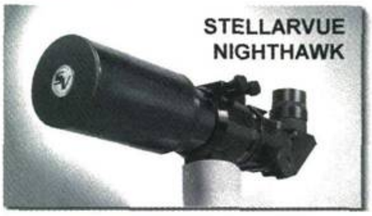

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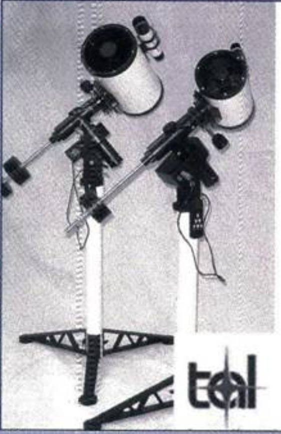

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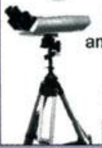

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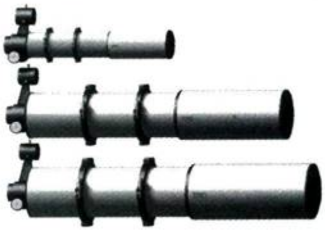

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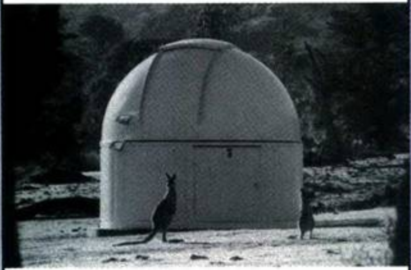

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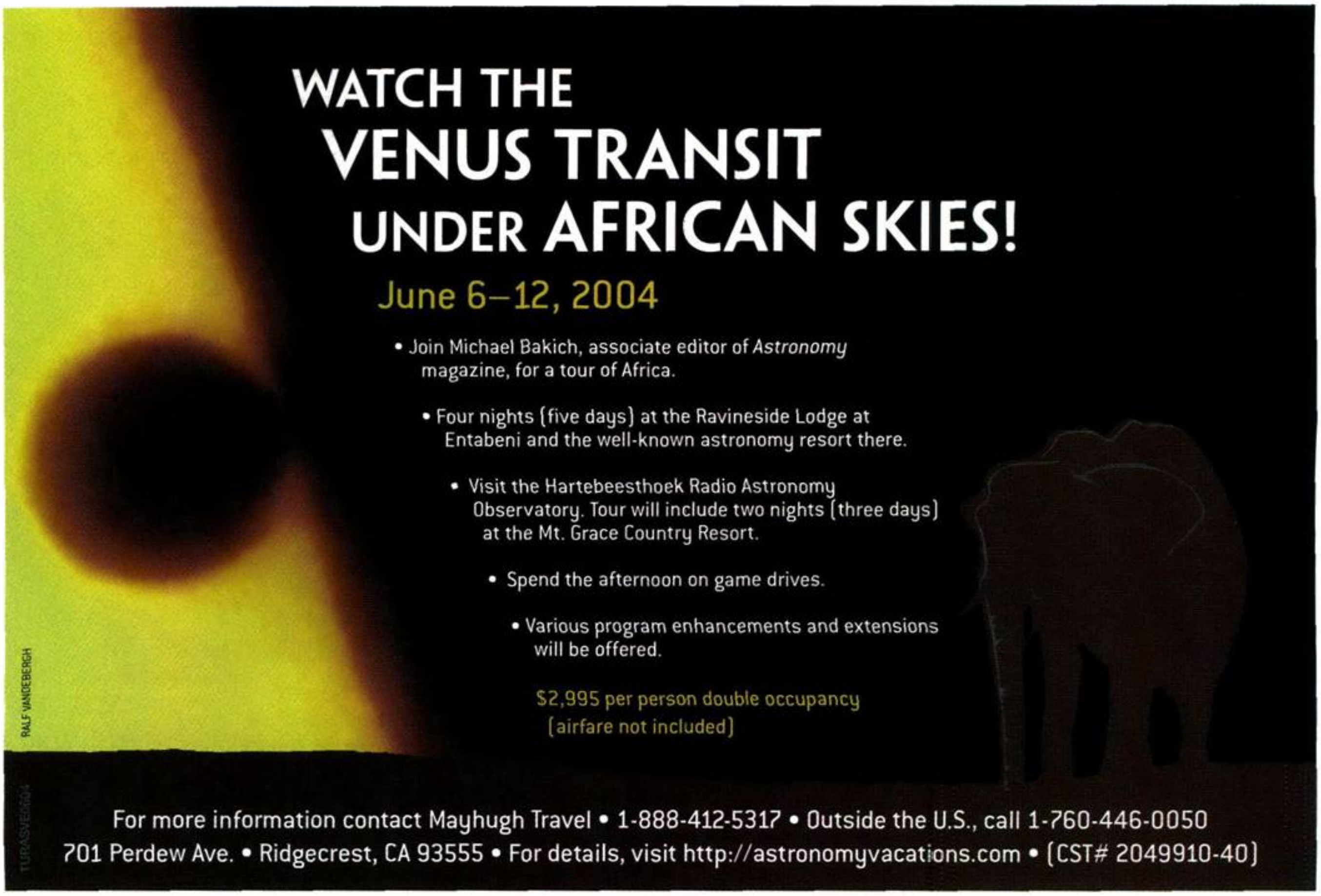

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NEXT MONTH

Black holes
Astronomers have found small black holes, and they also see evidence for supermassive ones in the cores of galaxies. But how do the little guys become big ones? New theories hold promise.

Snowflakes to "Plutos"
It takes a billion billion snowflakes to make a comet, and a billion comets to make a planet like Pluto. Learn how snowstorms in space formed the icy bodies at the far reaches of our solar system.

The survivor
Interstellar clouds eat star clusters like M67 for breakfast. Find out how this ancient object has cheated death for nearly 5 billion years.

Under the sea
Nearly impossible to catch, neutrinos offer a valuable window on the cosmos. A new observatory deep under the Mediterranean Sea may soon capture loads of these mysterious subatomic particles.

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05.16.04–05.23.04

For 25 years, dedicated amateur astronomers from around the world have descended on the Prude Ranch near Fort Davis, Texas. This year will be no different as seasoned veterans return to observe under dark skies at the Texas Star Party (TSP).

THE TEXAS STAR PARTY offers stunning scenery, such as this view of the surrounding hills and the McDonald Observatory resting in the background. DOUG RICHTER

The TSP, the state's most popular star party, is known for its no-nonsense "observing atmosphere." Besides sky watching, other activities include tours of nearby McDonald Observatory, lectures, workshops, imaging, horseback riding, hiking, and a swap meet.

Although a drawing for visitor passes was held in January, a few openings usually occur after this deadline.

For more information, contact Anne Archer, the TSP registrar, at 512.451.8895 (day) or 512.451.0339 (evening); e-mail, tspreg@metronet.com; web site, www.texasstarparty.org.

02.07.04–02.08.04

European Astrofest

Kensington Town Hall, London, England. In its 11th year, European Astrofest will feature numerous exhibitors and speakers. *Astronomy* editor Dave Eicher will be in attendance, lecturing on planetary nebulae and other deep-sky wonders. For more information, call 01732.367542; web site, www.astronomynow.com/astrofest.

02.12.04–02.16.04

American Association for the Advancement of Science Annual Meeting

Washington State Convention and Trade Center and the Sheraton Seattle Hotel and Towers, Seattle. The theme of this year's annual gathering is "Science at the Leading Edge." This AAAS meeting will examine all other disciplines of science, including astronomy. For more information, visit www.aaas.org.

02.16.04–02.21.04

Winter Star Party

Camp Wesumkee, West Summerland Key, Florida Keys. Sponsored by the Southern Cross Astronomical Society, the Winter Star Party celebrates its 20th annual gathering. Twelve-hour observing sessions at this dark-sky site will provide ample time to target celestial beauties. *Astronomy* associate editor Vanessa Thomas will be in attendance. For more information, visit www.scas.org.

02.18.04–02.22.04

Orange Blossom Special Star Party

Hickory Hill Observing Complex, near Brooksville, Florida. Highlights of the Orange Blossom Special will include day and nighttime observing, workshops, lectures, a swap table, door prizes, a music jam session, and a special youth program. For more information, visit home1.gte.net/hoffmanc/index.html.

03.17.04–03.21.04

Kisatchie Star Party

Kisatchie National Forest, Louisiana. Sponsored by the Baton Rouge Astronomical Society, this star party features dark skies, camping, hiking, and canoeing. For more information, visit www.bro.lsu.edu/bras/kisatchie.html.

04.14.04–04.17.04

Mid-South Star Gaze

Rainwater Observatory, near French Camp, Mississippi. Designed for anyone interested in learning about astronomy, this gathering will feature lectures, a teacher workshop, a swap meet, and informal day and nighttime observing sessions. For more information, e-mail rainwater@astronomers.org; web site, www.rainwaterobservatory.org/stargaze.

04.17.04–04.25.04

Astronomy's Hawaiian Tour

Various locations throughout Hawaii. Join *Astronomy*'s managing editor Patricia Lantier on a guided tour of the observatories of Mauna Kea and other sites of the island paradise. Although the trip will be largely group-based, there will be plenty of time to enjoy the local activities solo. For more information, contact Mayhugh Travel at 888.412.8317 (U.S.) or 760.446.0050 (international); web site, www.astronomyvacations.com or www.astronomy.com/content/static/trips/hawaii.asp.

04.23.04–04.24.04

NIAGfest Astronomy Convention and GreatCon

Camp Crosley, North Webster, Indiana. Cosponsored by the Northern Indiana Astronomical Group and the Great Lakes Region Astronomical League, this is the 18th annual gathering at Camp Crosley. Lodges are available on-site, as well as camping spots. For more information, contact NIAGfest Registration, 1308 Sunset Drive, Winona Lake, IN 46590; phone, 574.269.1856 (after 5 P.M.); e-mail, jtague@kconline.com; web site, clubs.kconline.com/was/niag.htm.

04.30.04–05.01.04

North Central Region of the Astronomical League Star Party and Convention

John H. Witte Observatory, Big Hollow Recreation Area, near Burlington, Iowa. The Southeastern Iowa Astronomy Club will celebrate its 20th anniversary during this annual gathering. The convention portion of the weekend will take place at Southeastern Community College in West Burlington. For more information, e-mail dbphilabaum@mchsi.com; web site, www.seiac.com.

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CONTACT INFORMATION

Please submit club announcements four months in advance to Coming Events, *Astronomy*, P. O. Box 1612, Waukesha, WI 53187, or jmcgovern@astronomy.com. Add your events to our on-line calendar at www.astronomy.com.

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RESOURCES

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GREATEST ASTROPHOTOS IN HISTORY

BOOKS — Historic astrophotos and scientific breakthroughs often go hand-in-hand. *The Discovery of Our Galaxy* by astronomer Charles Whitney (Alfred A. Knopf, New York, 1971), for example, details the realization that the much photographed milky band of stars in the sky is actually our galaxy. Likewise, learn about the birth of extragalactic astronomy and cosmology in *Man Discovers the Galaxies* by Richard Berendzen, et al. (Science History Publications, New York, 1976).

Agnes M. Clerke's *A Popular History of Astronomy During the Nineteenth Century* (1885; reprint, Sattre Press, Decorah, Iowa, 2003) is an excellent resource on historic "firsts" in astrophotography. *The Harvard College Observatory: The First Four Directorships, 1839–1919* by Bessie Z. Jones and Lyle G. Boyd (Harvard University Press, Cambridge, Massachusetts, 1971) includes diary entries and writings by father and son astrophotography pioneers William and George Bond. The latter writes that "one of the first applications of [stellar photography] would be the measurement of the angles of position and distance of double stars."

ARTICLE — Astronomer David Malin describes groundbreaking color emulsion techniques that allowed faint objects to be resolved in "Exploring the image" (*Astronomy*, November 1979).

WEB — Learn about the Daguerreian process at www.daguerre.org/resource/process/remin.html and about wet-plate collodion photography at www.collodion-artist.com/History/.

You can find a press release marking the 150th anniversary of the first photograph of a star at cfa-www.harvard.edu/newtop/previous/071700.html.

ON THE TRAIL OF VULCANOIDS

ARTICLE — The quest to locate an object — or objects — inside the orbit of Mercury has a rich history, although the search for a planet-size body ultimately fell short. Find out more in "Vulcan chasers" by William Sheehan and Richard Baum (*Astronomy*, December 1997).

STAR LIGHT, STAR BRIGHT

BOOKS — All the bright supernovae in our galaxy exploded before the telescope was invented, so the only way modern astrophysicists can learn about nearby supernovae is to study historic occurrences. In *Historical Supernovae and their Remnants* (Oxford University Press, New York, 2002), F. Richard Stephenson and David A. Green discuss the nature of (and problems in) extracting usable data from historical records. They provide a semi-technical overview of supernovae, pulsars, and remnants and also examine five pre-telescopic supernovae (A.D. 1006, 1054, 1181, 1572, and 1604) in detail.

For a general overview of how massive stars form, evolve, and explode, take a look at James Kaler's *Extreme Stars* (Cambridge University Press, New York, 2001).

WEB — Supernovae are a popular research topic in astrophysics; visit rsd-www.nrl.navy.mil/7212/montes/sne.html to find a huge, well-categorized list of links.

In addition to other, general topics, this web site contains catalogs of supernovae, links to web pages for both individual researchers and research groups, preprints of scientific papers, and meeting notices. The site is geared toward professional astronomers, but anyone fascinated by these gigantic stellar explosions will find lots of interesting material.

ORION

BOOKS — Written for amateur astronomers, *Observing Handbook and Catalogue of Deep-Sky Objects* by Christian B. Luginbuhl and Brian A. Skiff (Cambridge University Press, New York, 1990) presents an organized and descriptive list of deep-sky objects in each of the sky's constellations. It also provides advice on how to observe these objects, including what tools are necessary.

If you're interested in reading more about the history of constellations, *The Constellations: An Enthusiast's Guide to the Night Sky* by Lloyd Motz and Carol Nathanson (Doubleday, New York, 1988) will serve you well. Organized by season, the book details both the mythology of the constellations and the science behind the celestial objects they contain.

ARTICLE — To learn more about the science behind Orion's most famous nebula, read "Style & substance" by Ray Jayawardhana (*Astronomy*, October 2003).

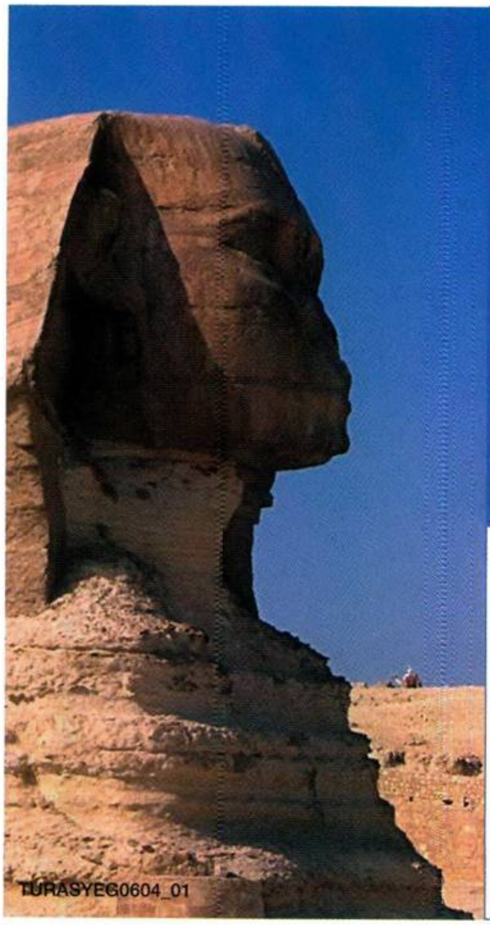
CCD IMAGES AT THEIR BEST

BOOKS — *The New CCD Astronomy: How to Capture the Stars with a CCD Camera in Your Own Backyard* by Ron Wodaski (New Astronomy Press, Duvall, Washington, 2002) is an excellent book for beginning and intermediate CCD imagers; it contains more information about CCD cameras, their application to astronomy, and the techniques discussed in the article.

A reference that describes how to post-process images (how to improve images once you've captured them with your CCD camera) is the CD-ROM book *Photoshop for Astrophotographers* by Jerry Lodriguss (Astropix, Sommerdale, New Jersey, 2003). Tips and techniques in this book range from beginning to advanced.

WEB — Tony Hallas and his wife Daphne maintain a web site with many stunning celestial images at www.astrophoto.com.

CCD imagers also target planets. Because planets are bright, they can be imaged from any location. Astrophotographer Ed Grafton does his work from Houston, Texas. Check out his web site at www.ghg.net/egrafton. And don't miss Robert Gendler's image gallery; he sets up his equipment in his driveway in Connecticut — talk about post-processing! You can find his spectacular shots at www.robgendlerastropics.com.



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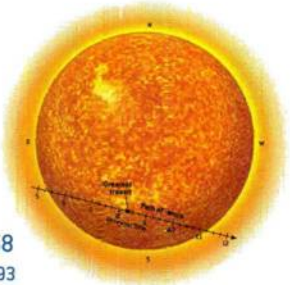

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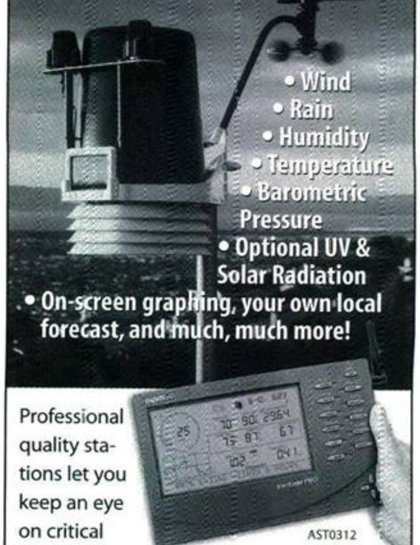

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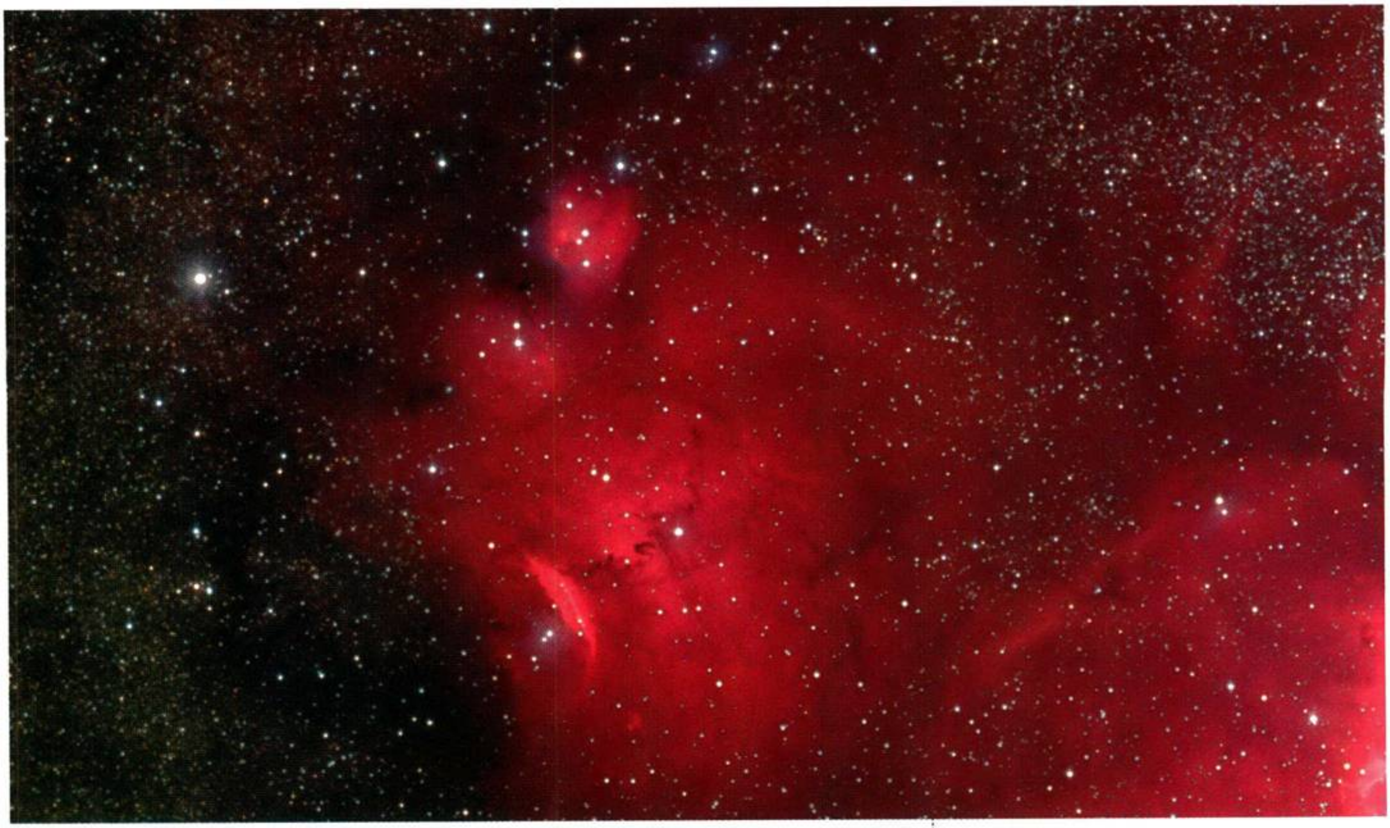
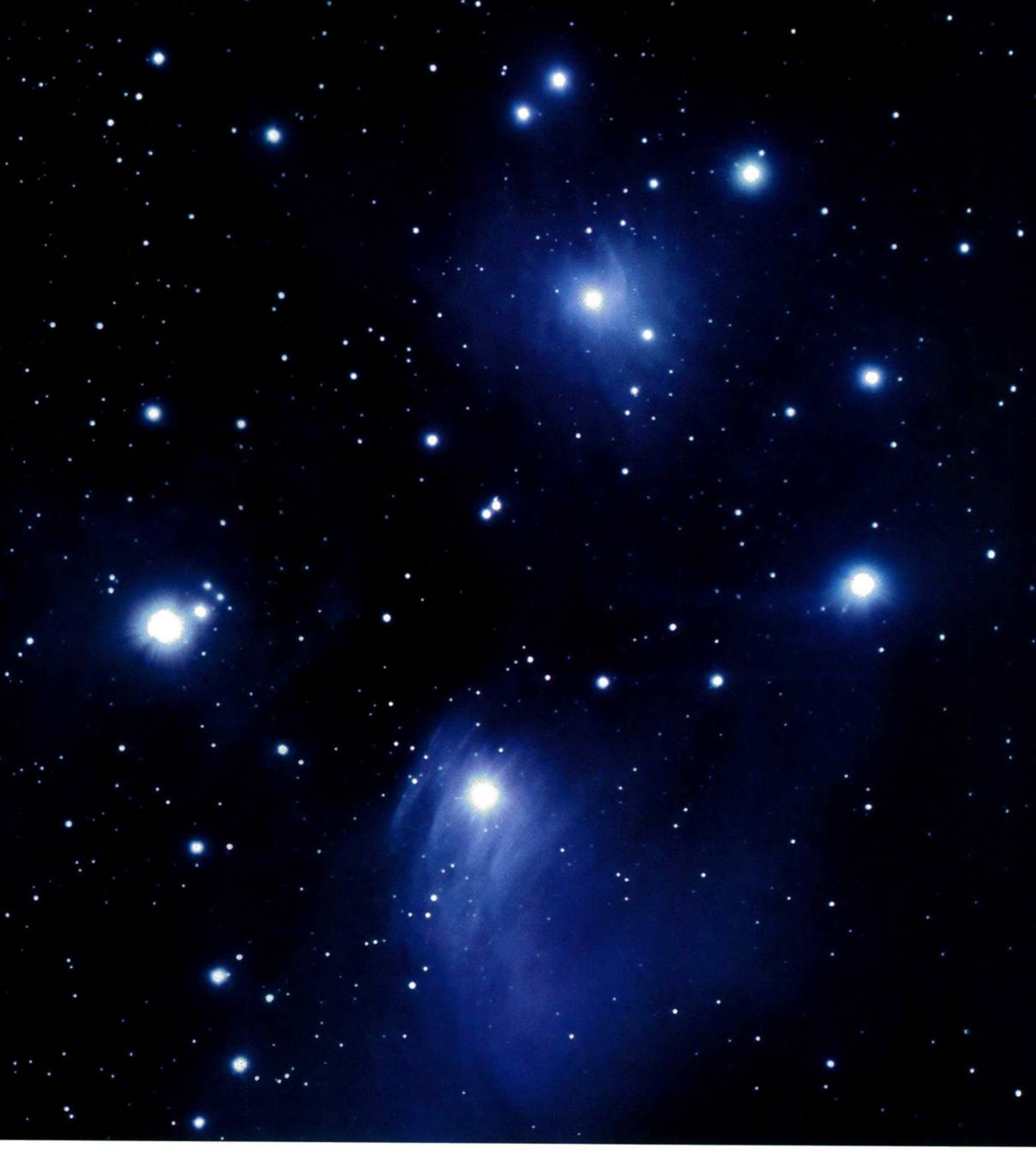


Above, **EMISSION NEBULA NGC 6559 IN SAGITTARIUS** (4-inch Takahashi FSQ106 refractor at f/5.3, SBIG ST-10XME CCD camera, LRGB image of 40, 40, 10, and 32 minutes, respectively, taken April 6, 2003, from Oceanside, California) /// **DANIEL B. PHILLIPS**

BETWEEN THE STARS

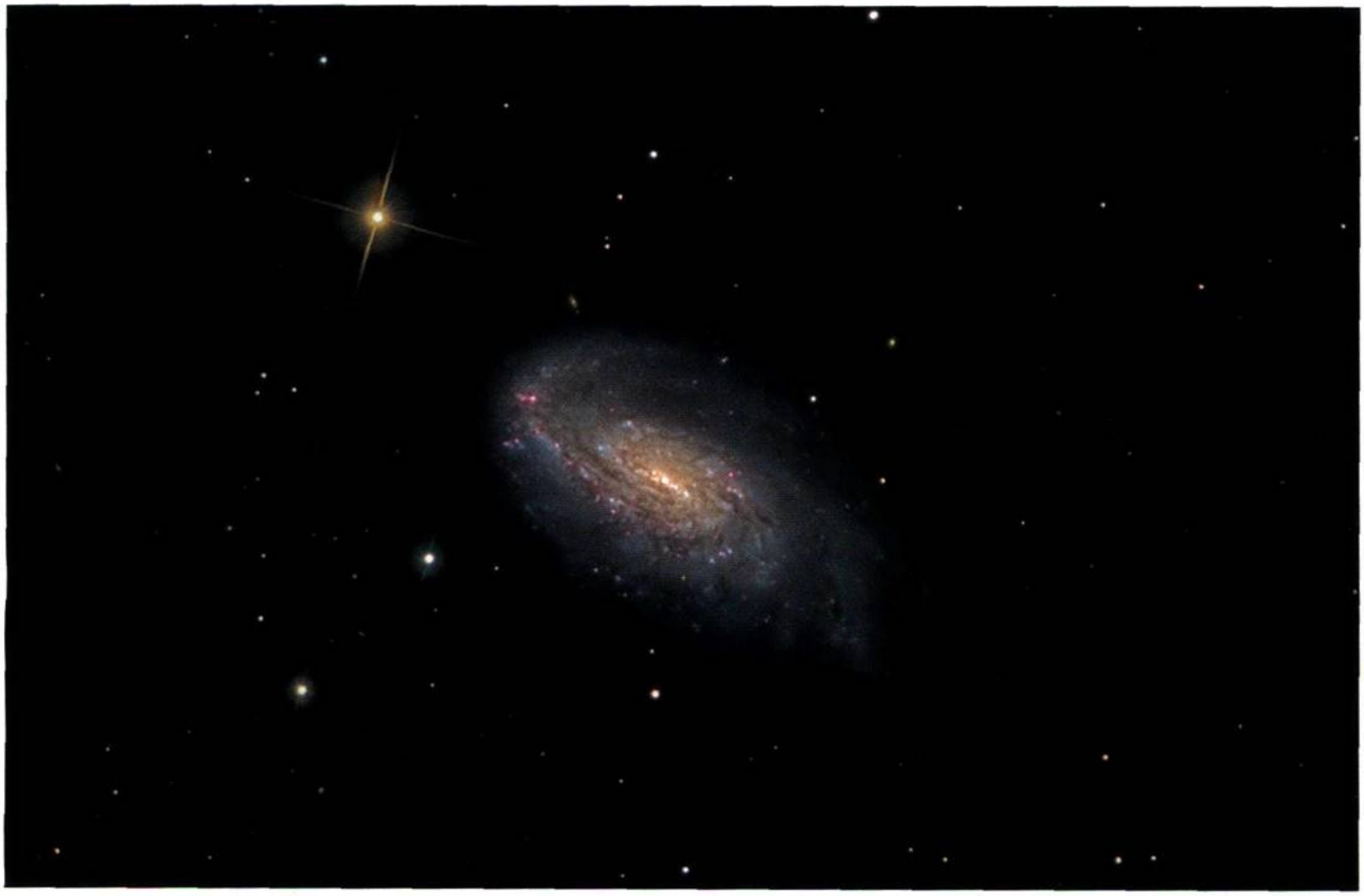
A nebula complex

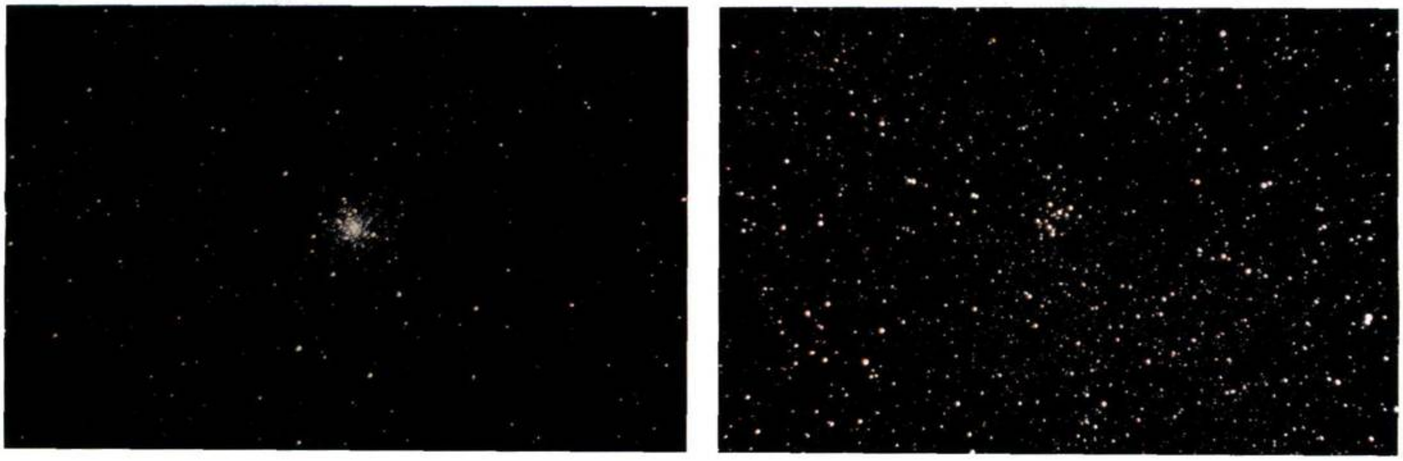
NGC 6559 lurks in the constellation Sagittarius the Archer. Its red color is created when radiation from nearby stars ionizes interstellar hydrogen. Ionization occurs when one or more electrons in an atom are moved to higher energy levels after being struck by photons of radiation. Electrons prefer their original energy levels, however, and re-radiate the energy they absorbed, which we see as light. Because nebulae are made of hydrogen, this light usually has a reddish hue. Images of NGC 6559 taken with large telescopes reveal two areas of bluish light. Dust particles, which reflect blue light best, are the cause. Dust also absorbs visible light in this nebula, creating the dark clouds and filaments.



Above, **THE PLEIADES (M45) IN TAURUS** (3.5-inch Meade LX90 Schmidt-Cassegrain telescope at f/6.3, Canon 10D digital camera at ISO 1600, thirty exposures between 6 and 9 minutes each combined into a six-section mosaic, taken September 29, 2003) /// **STEPHEN CANNISTRA**

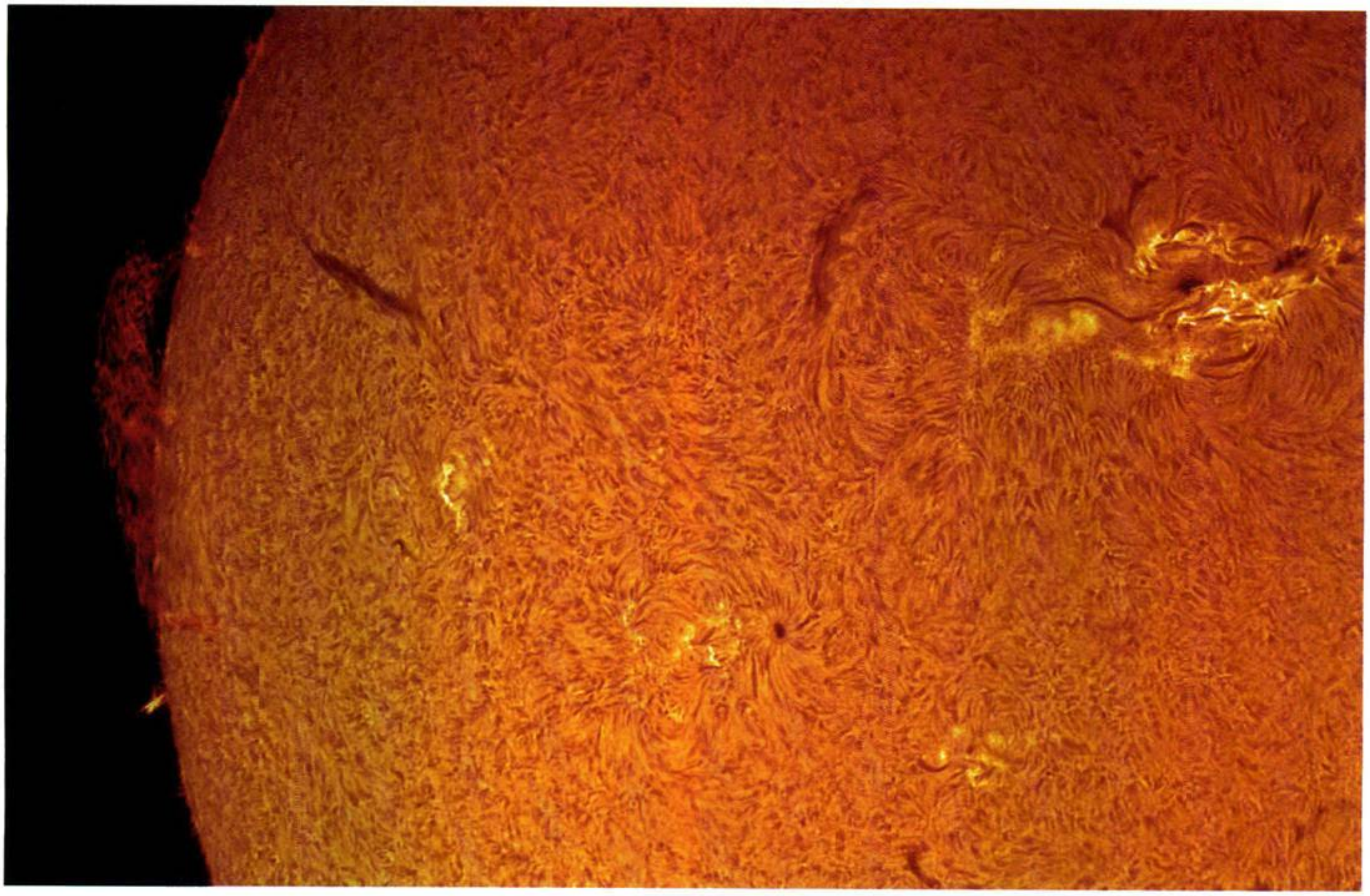
Send photos to: Astronomy Reader Gallery, P.O. Box 1612, Waukesha, WI 53187; e-mail to readergallery@astronomy.com. Please include your name, date and location of image, and complete photo data: telescope, camera, film, and exposure information.





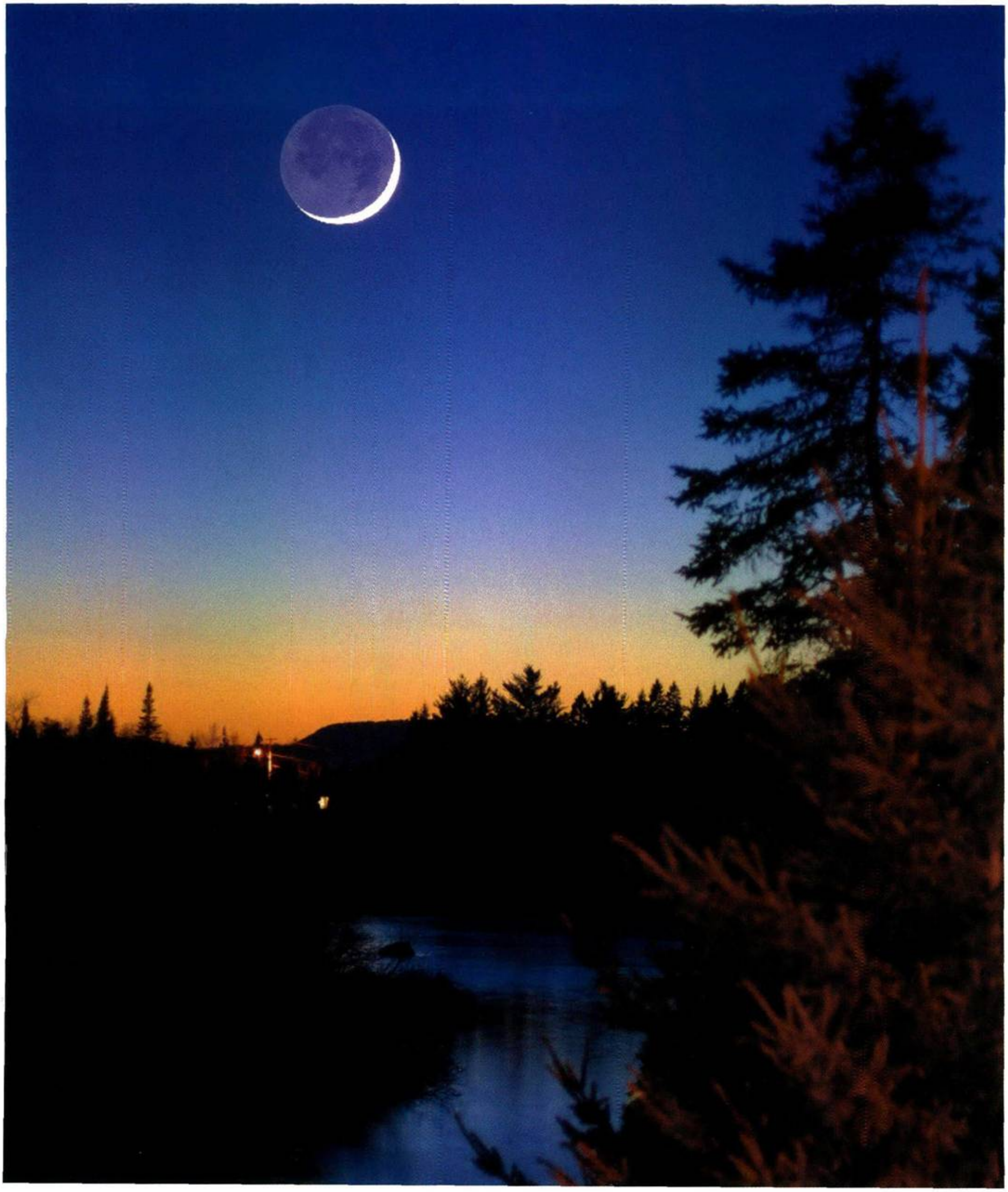
Top, **SPIRAL GALAXY NGC 4654 IN VIRGO** (RC Optical Systems 20-inch Ritchey-Chrétien at f/8.4, SBIG ST-10XME CCD camera, LRGB image with exposures of 90, 20, 20, and 20 minutes, respectively) /// **MITCH AND MICHAEL DAY AND ADAM BLOCK**

Bottom sequence, **FOUR SELDOM IMAGED MESSIER OBJECTS** (M39 in Cygnus [above left]: 20-minute exposure, August 28, 2002; M26 in Scutum [above right]: 20-minute exposure, June 26, 2003; M12 in Ophiuchus [opposite lower left]: 30-minute exposure, September 12, 2002; M29 in Cygnus [opposite lower right]: 20-minute exposure, August 28, 2002. All were imaged through a 10-inch Newtonian reflector at f/5, Ektachrome Professional 200 film, from Atascadero, California.) /// **LEE C. COOMBS**



Top, **THE ACTIVE SUN** (5-inch Meade 127ED apochromatic refractor at f/9, Pictor 1616XTE CCD camera, stacked 90mm and 60mm Coronado Technology Group hydrogen-alpha filters, taken June 7, 2003, from Chiefland, Florida) /// **JACK NEWTON**

Below, **EARLY EVENING EARTHSHINE** [Canon D30 digital camera, 200mm lens at f/2.5, 1.5-second, tripod-mounted exposure, taken May 3, 2003, from Shannon, Quebec, Canada] /// **JAY OUELLET**



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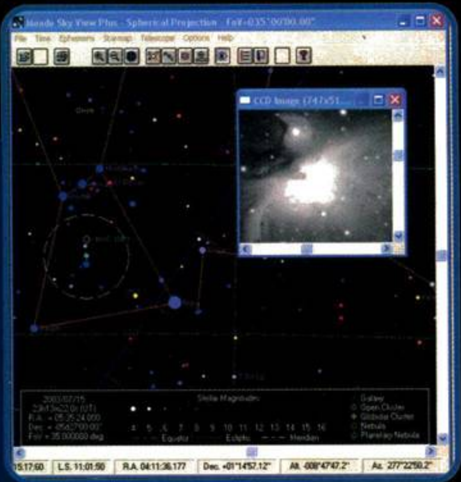

Planetarium program showing Orion region.

Image of Saturn by Jeff Hobbs taken with an LPI connected to a 12" LX200GPS. The image is a composition of images automatically selected and registered by the Autostar Suite software.

Moon image taken with altazimuth mounted 8" LX90 by first-time user of the LPI imager and software.

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